# Operative Surgery



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# OPERATIVE SURGERY

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# CHAPTER 46

# ABDOMINAL INCISIONS

Benjamin W. Rawles, Jr.

Although the first and last steps of every abdominal operation are the making and the closing of the incision, these steps may appear to be inconsequential as compared to the details of the procedure performed in between. The success of an operation, however, may depend in part, at least, on whether adequate exposure is provided by the incision selected and also on whether the incision is closed satisfactorily without the development of wound infection, wound separation and evisceration, and postoperative ventral (incisional) hernias.

In the past, some type of vertical rectus incision has been preferred by most surgeons, but in recent years there has been a trend to the use of transverse abdominal incisions, particularly in surgery of the upper abdomen, as a result of a better appreciation of the anatomical structure of the abdominal wall. The rectus sheath is formed by the aponeurotic fibers of the flat abdominal muscles, the external oblique, internal oblique, and transversus abdominis. These fibers run generally in a transverse direction, never varying more than 30 degrees from the transverse, according to Coller. There is, therefore, a much greater pull from side to side than there is in the vertical direction. The approximated edges of a vertical incision are thus subjected to a much greater pull in a direction at right angles to the direction of the incision as compared to a transverse incision.

A firm abdominal musculature following incision of the wall may depend on preservation of the motor nerves to the recti muscles. The musculature is supplied by the lower six intercostal and the first lumbar nerves. These nerves are so interconnected that one, and possibly two, may be severed without affecting the segmental nerve supply. The course of the nerves is generally in a transverse direction. A vertical incision, with the exception of a midline or paramedian, therefore, more frequently may damage two or more nerves, with segmental musculature atrophy resulting, if the incision is of any great length. A transverse incision, on the other hand, runs in the general direction of the course of the nerve fibers so that there is less chance of injuring as many as two nerves.

A vertical incision may be advantageously used under some circumstances. First, the abdominal cavity can be entered quickly in case of emergency surgery; second, the incision can be extended upward or downward when exploration reveals the pathology to be away from the site of the original incision, although it may be the better practice to close the original incision and make a second properly placed

one over the site of the pathology; third, a short vertical paramedian incision is preferred to a McBurney incision for an appendectomy when the tentative diagnosis is chronic recurrent appendicitis in either sex, since the vertical incision more easily permits exploration of the pelvis or the rest of the abdominal cavity.

Transverse incisions require accurate localization of the pathology for proper placing of the incision, although they can be extended across the other rectus, or laterally, or a vertical limb can be added to give more adequate exposure. The many other advantages of the transverse incision make it the incision of choice for many surgical procedures First, it provides adequate exposure without heavy pulling with a retractor against the abdominal wall, as is so often necessary for exposure with a vertical incision; second, there is minimum trauma to nerves; third, the incision closes with ease because there is minimal pull or tension perpendicular to the axis of the incision; fourth, the patient has minimal discomfort in the immediate postoperative period; fifth, incisional hernias rarely occur as a complication; sixth, wound separation and evisceration are less frequent than with vertical incisions

Better exposure for certain operative procedures in the upper abdomen may be provided either through a transthoracic approach or through a thoracicoabdominal incision. During World War II military surgeons found that the organs in the upper abdomen could be adequately exposed through the diaphragm at the time of thoracotomy in the case of combination thoracicoabdominal injuries. Transthoracic incisions have been employed by some surgeons for the resection of lesions in the region of the esophagogastric junction. Carter has advocated a thoracicoabdominal incision for splenectomy and as the approach to lesions involving the upper end of the stomach or lower end of the esophagus Satinsky suggested that it be employed in portacaval anastomosis

## TYPES OF INCISIONS

### Vertical Paramedian Rectus Incision

This incision can be used in the upper, mid-, or lower abdomen, on either the right or the left (Fig. 547). The anterior rectus sheath is incised vertically for the desired length 1 to 3 cm. from the midline, and the rectus muscle is retracted laterally. In this way the motor nerves, which enter laterally, are not injured. The posterior rectus sheath and peritoneum are opened vertically in approximately the same plane as the anterior sheath. After closure the muscle acts as a buttress between the incisions in the anterior and posterior sheath. This type of incision on the left, extending from the symphysis pubis to a point above the umbilicus, provides excellent exposure for resection of the rectum and sigmoid colon. A similar incision placed on either side also provides good exposure for gynecologic surgery. A shorter incision, centered just below the umbilicus on the right, is ideal for exploration of the lower abdomen or for appendectomy when there is question as to the pathology The incision may be used on the right in the upper abdomen to approach the liver, gall bladder, common duct, pancreas, duodenum, or stomach, or on the left for the spleen or stomach This incision, particularly in the upper abdomen, is exposed to excessive strain when there is postoperative nausea and vomiting or violent coughing episodes with a higher incidence of wound separation

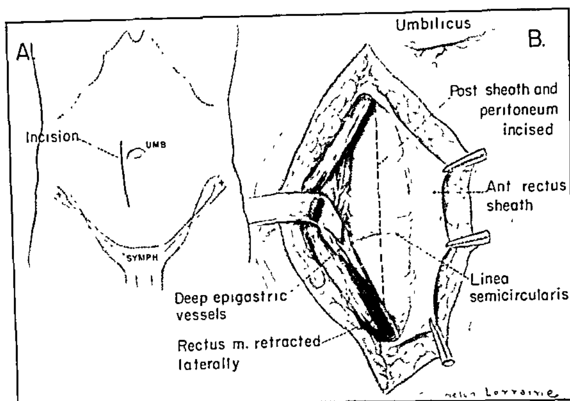



Fig 547.—Vertical paramedian rectus incision

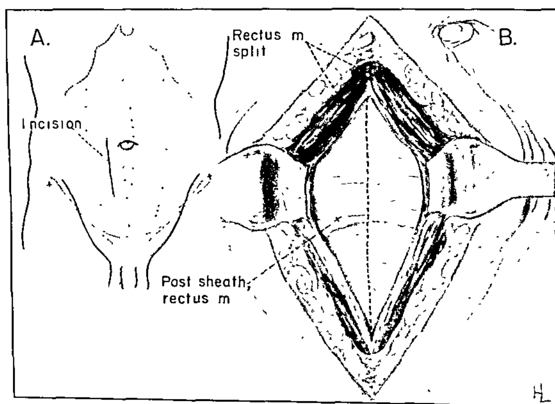



Fig. 548.—Vertical rectus muscle-splitting incision.

and incisional hernia than is experienced with a transverse incision. A mid-paramedian incision may be used as the approach to the ascending, transverse, or descending colon.

### Vertical Rectus Muscle-Splitting Incision

The incision is made through the skin, subcutaneous tissue, anterior and posterior sheaths, and peritoneum, as in the paramedian, but the muscle fibers are split and the incision is carried straight through instead of around the mesial border of the muscle (Fig. 548). The peritoneal cavity can be entered quickly and the incision extended, if necessary, but the nerve supply to the mesial portion of the muscle may be so damaged that atrophy results if the incision is of any great length. The incision is used as the approach for the same procedures as the paramedian incision.

### Vertical Midline Incision

This incision extends through the relatively avascular linea alba. It may be used in the upper or lower abdomen. The abdominal cavity is entered quickly through it and the incision may be extended by curving it about the umbilicus. There are disadvantages from the standpoint of repair, as the incision is at the midpoint of the transverse pull of the flat muscles from either side.

### McBurney Muscle-Splitting Incision

The McBurney incision is the ideal incision for removal of an acute appendix (Figs. 648-654). The details of the incision are described in the section on appendicitis (Chapter 58). If necessary, it can be extended transversely across the rectus muscle and the anterior and posterior rectus sheaths to provide more exposure, as was first described by Harrington and Weir. This incision may also be used for cecostomy or, on the left side, for sigmoid colostomy.

### Upper Quadrant Transverse Incision (Subcostal)

This incision may be used on either side On the right it is an ideal incision for cholecystectomy, while on the left it may be used for splenectomy. The incision may be a true transverse, or it may be made obliquely in the general line of the lower costal border, but it is actually a transverse incision, since the division of the rectus muscle and fascia is generally in the transverse direction. The incision begins in the midline midway between the xiphoid and umbilicus and runs laterally and slightly downward to a point in the anterior axillary line just below the lower costal margin (Fig 549, *A*). The anterior rectus sheath is divided transversely and the muscle is exposed (Fig. 549, *B*). The muscle is divided transversely. The posterior sheath and peritoneum are then opened transversely (Fig. 549, *C*). If the rectus is broad, adequate exposure is provided without extension laterally, but, if necessary, the external oblique is retracted laterally and the internal oblique and transverse muscles split in the line of the peritoneal incision. More exposure can also be provided by carrying the incision across the sheath of the left rectus with retraction or transverse division of the muscle The falciform ligament is divided if this is done.

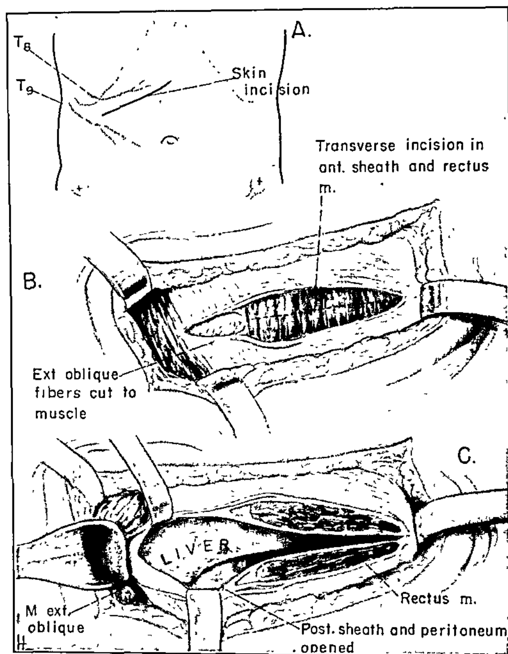



Fig. 549 —Upper quadrant transverse incision (subcostal).

## Upper Abdominal Transverse Incision

This incision gives adequate exposure for operations on the stomach, duodenum, and pancreas. It is ideal for gastrectomy and pancreatoduodenectomy. The incision extends from a point just below the costal margin on one side in the anterior axillary line to the same point on the opposite side and is curved (concavity downward) with the mid-point lying approximately midway between the xiphoid

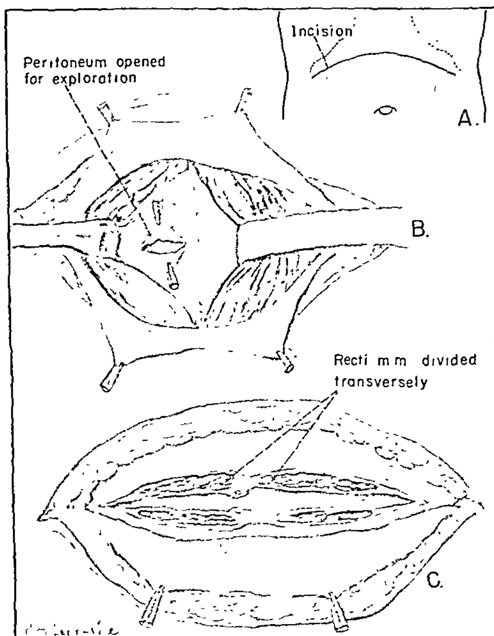



Fig. 550.—Upper abdominal transverse incision.

and the umbilicus (Fig. 550, *A*). The anterior rectus sheath on either side is divided transversely and the recti muscles are exposed. If there is any question as to operability, the recti muscles can be retracted laterally and the posterior rectus fascia and peritoneum divided transversely to permit exploration before unnecessarily dividing the recti muscles (Fig. 550, *B*) as is done in the Sanders modification of the Sloan incision. If the lesion is found to be operable, the muscles are divided transversely. At the lateral aspects of the incision the external oblique muscle is

retracted or divided and the internal oblique and transversalis abdominis muscles are split in the line of the incision (Fig. 550, *C*). The intercostal nerves are preserved, if possible, but one, and even possibly two, can be divided without causing segmental muscle atrophy.

## Midabdominal Transverse Incision

This incision begins slightly above or below the umbilicus on either the right or the left side and is carried laterally into the flank (Fig. 551, *A*). If necessary, it can be extended across the opposite rectus sheath and muscle. It provides good

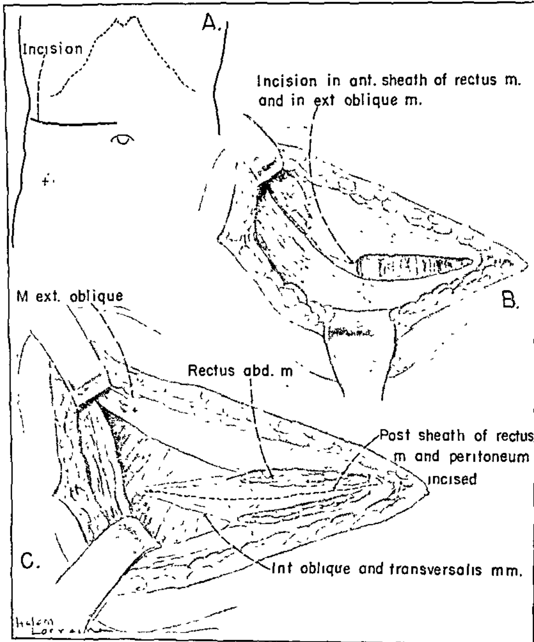



Fig. 551 —Midabdominal transverse incision.

exposure for the ascending and the descending colon It also provides a good retroperitoneal approach for lumbar sympathectomy, vena cava ligation, and for removal of retroperitoneal tumors. The anterior rectus sheath is divided transversely and the incision extended upward and laterally in the line of the fibers of

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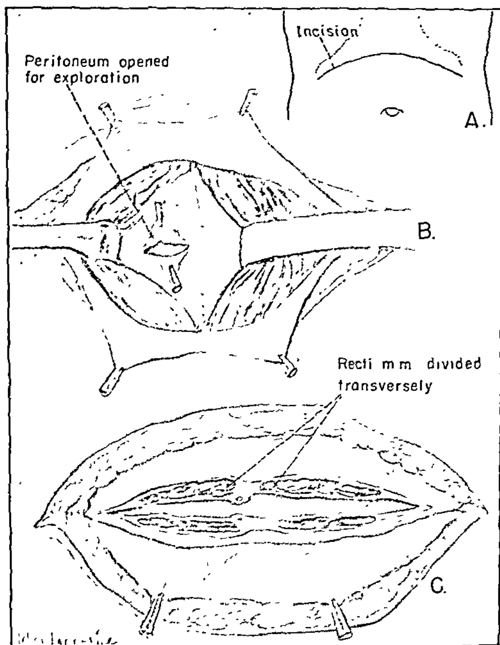



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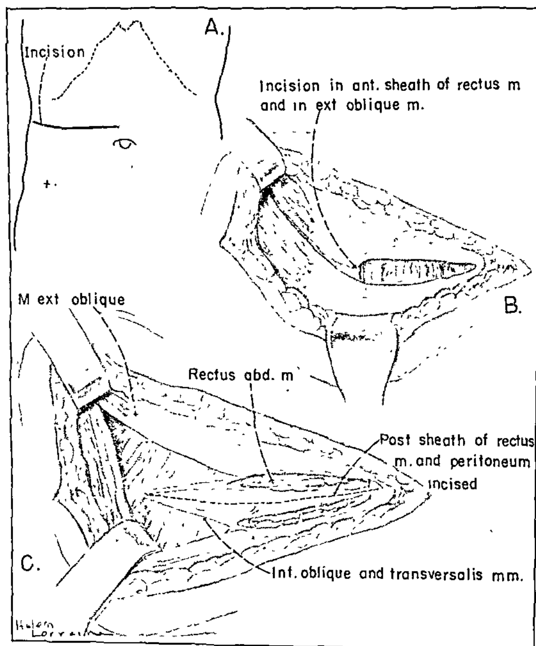



Fig 551.—Midabdominal transverse incision

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the external oblique (Fig. 551, *B*). The rectus muscle is divided transversely. The posterior sheath and peritoneum are incised transversely, care being taken to preserve the intercostal nerves as they run over the posterior sheath (Fig. 551, *C*). The incision in the posterior sheath and peritoneum is carried laterally, splitting the fibers of the internal oblique and transverse abdominis to provide adequate exposure.

## Diagonal Incision for Resection of Colon (Coller)

This incision can be used for abdominoperineal resection of the rectum and sigmoid colon and anterior resection of sigmoid colon and upper rectum with primary anastomosis. As described by Coller, the incision begins just above the symphysis to the right of the midline and extends laterally on the left to the outer border of the rectus and then upward in the line of the fibers of the external oblique to a point just above and mesial to the anterior superior iliac spine (Fig. 552, *A*).

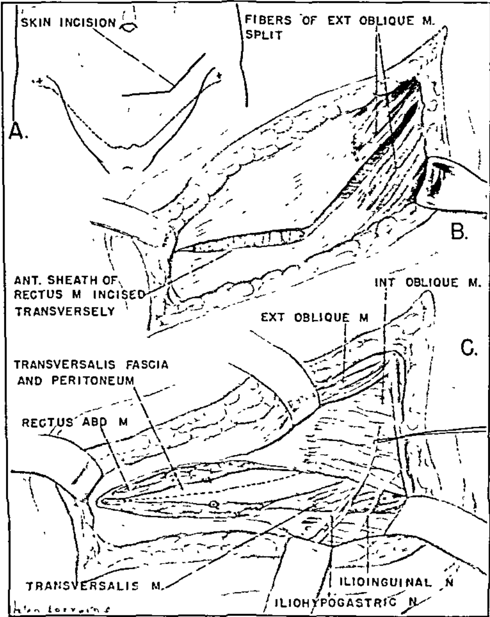



Fig. 552.—Lower quadrant transverse incision (Coller).

The anterior rectus sheath is incised transversely and the incision is carried laterally and upward splitting the fibers of the external oblique, aponeurosis, and muscle (Fig. 552, *B*). The iliohypogastric nerve, running downward and mesially beneath the external oblique, is carefully isolated and retracted downward. The rectus muscle is divided transversely. The peritoneum and transversalis fascia are opened transversely and the incision is carried laterally, splitting the internal oblique and transversus abdominis muscles in the line of their fibers (Fig. 552, *C*). The incision can be extended to the right across the opposite rectus, if necessary.

Thoracicoabdominal Incision (Carter)

A transverse incision is made from a point midway between the xiphoid and the umbilicus to the costal margin at the site of the eighth costal cartilage. (Fig. 553.) If it is planned to use the incision for total gastrectomy for carcinoma, the lesion can first be explored through the abdominal portion to determine operability before extending the incision into the thorax. Otherwise, the incision is extended in the line of the eighth interspace to the midscapular line. The rectus and oblique

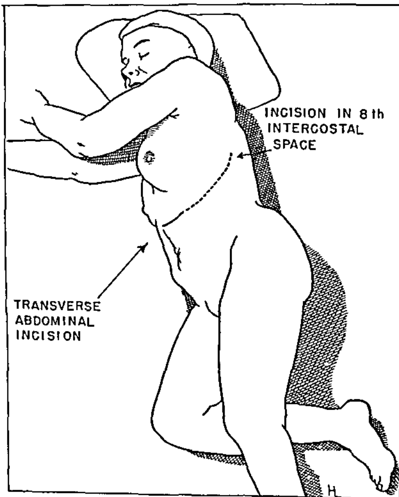



Fig. 553.—Thoracicoabdominal transverse incision (Carter), showing position of patient and line of incision.

abdominal muscles and the thoracic muscles are divided in the line of the incision down to the peritoneum and pleura (Fig. 554). These are opened and the costal cartilage is divided. The diaphragm is then divided from the costal margin attachment to the posterior angle of the thoracic wound (Fig. 555). A rib spreader is

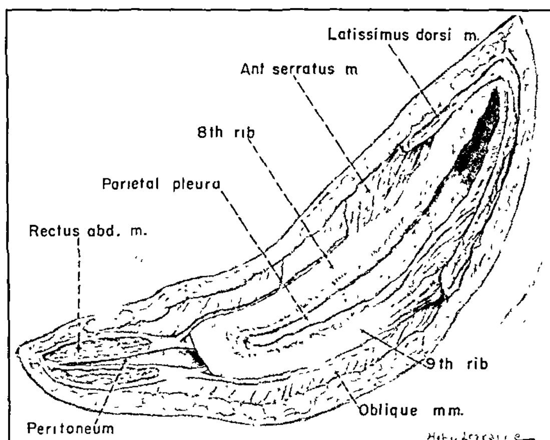



Fig. 554.—Thoracicoabdominal incision (Carter), the dissection carried down to the peritoneum and pleura

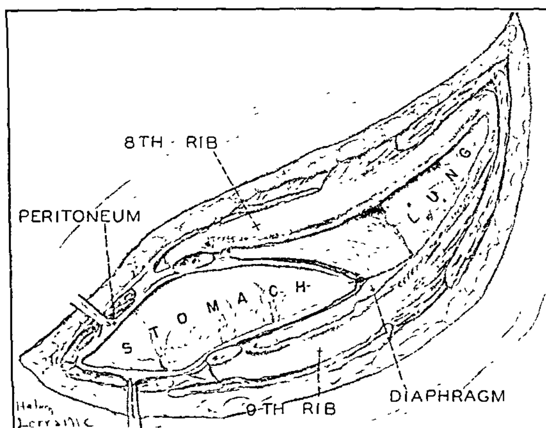



Fig 555—Thoracicoabdominal incision The costal cartilage and diaphragm have been divided and the stomach has been exposed.

inserted and exposure is obtained. The diaphragm is sutured with interrupted sutures of silk or cotton after the operative procedure has been completed. The ribs are reapproximated with one pericostal suture of braided silk and the intercostal structure with a continuous suture of chromic No. 0 catgut or continuous silk. The costal cartilage is reapproximated with interrupted sutures of cotton or silk placed in the perichondrium. The peritoneum and posterior fascial sheath are closed with a continuous suture of chromic catgut and the fascial layers, subcutaneous tissue, and skin with interrupted sutures of cotton or silk. The lung is carefully reexpanded before the chest wall is finally closed. Drainage is not absolutely necessary, but it is safer to insert a mushroom catheter in the ninth interspace, posterior axillary line, and to institute underwater drainage. The tube is removed in seventy-two hours.

## ABDOMINAL INCISIONS FOR GYNECOLOGIC OPERATIONS

Satisfactory exposure for most abdominal gynecologic surgery is provided through either a low paramedian or midline vertical incision. The transverse type of incision is preferred by some surgeons. The best-known transverse incision for pelvic surgery is the Pfannenstiel. In detail, it is similar to the Sanders modification of the Sloan incision except that the peritoneum is opened in the vertical instead of the transverse direction. This incision does not always provide adequate exposure. A true transverse incision with division of both recti muscles and the opening of the peritoneum in the transverse direction, however, can be used to provide better exposure. Division of the recti muscles through their tendinous insertion, as advocated by Cherney, provides more adequate exposure for radical panhysterectomy, although some difficulty may be encountered in resuturing the recti muscles to the symphysis pubis.

### Pfannenstiel Incision

The skin incision with the concavity upward is centered one-third of the way between the symphysis and the umbilicus and extends laterally on each side almost to the anterior superior iliac spines (Fig. 556, *A*). Both anterior rectus sheaths and the linea alba are divided transversely (Fig. 556, *B*). The muscles are retracted laterally after the overlying sheath flaps have been dissected upward and downward to free them. The peritoneum and transversalis fascia are finally incised in the vertical direction (Fig. 556, *C*). The incision may be modified to provide better exposure by dividing the recti muscles transversely and opening the peritoneum in the transverse direction. The incision can be carried further laterally by extending the incision in the rectus sheath obliquely upward and outward in the line of the fibers of the aponeurosis of the external oblique. The incision in the peritoneum and transversalis fascia is extended laterally to split the fibers of the internal oblique and transversus abdominis muscles.

### Cherney Incision

This incision is similar to the modified Pfannenstiel except that the recti muscles are divided at their tendinous insertion in the symphysis pubis. The pyramidalis muscles are detached above and turned downward (Fig. 557). The recti muscles are reattached to the symphysis pubis with heavy sutures of cotton or silk.

## Closure of Abdominal Incisions

A satisfactory closure of an incision requires absolute hemostasis, the incorporation of as small a volume of tissue in ties as possible, or the destruction of as little tissue as possible if the electrosurgical unit is used for the coagulation of bleeders, careful layer by layer approximation with appropriate size cotton, silk, or catgut, and the obliteration of all dead space.

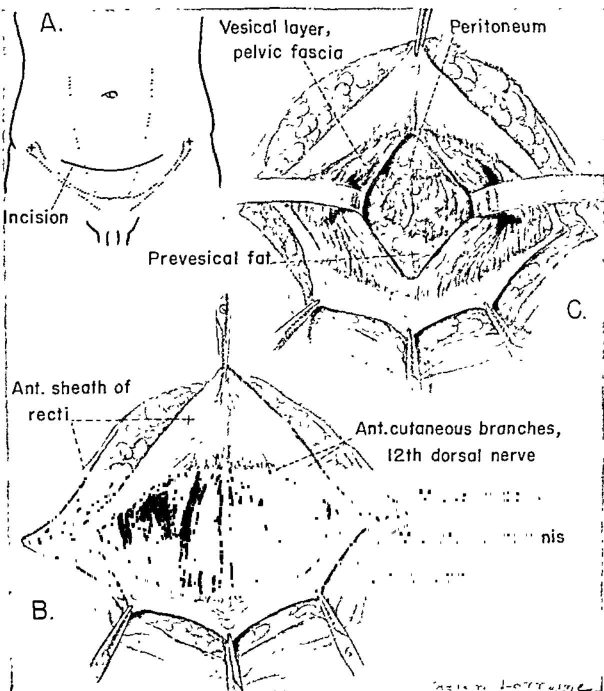



Fig 556 —Transverse (Pfannenstiel) incision (From Dodson: Urological Surgery, ed. 2, The C. V Mosby Co )

Careful closure of the peritoneum and also of the posterior sheath, if the incision is through it, is most important in order to prevent adherence of the intra-abdominal structures to the undersurface, and also to prevent wound separation

The peritoneum and posterior sheath are usually so adherent that no attempt should be made to separate them. The peritoneum and posterior sheath are closed with a continuous suture of No. 0 or 1 chromic catgut (Fig. 558, *A*). In vertical incisions an everting type of suture is used, if possible, since this leaves a smooth undersurface and also permits the approximation of the posterior sheath with interrupted sutures of cotton or silk. Some surgeons prefer to use interrupted nonabsorbable sutures in the peritoneum, but it is difficult to obtain a smooth approximation. In upper abdominal transverse incisions it is usually satisfactory to close the peritoneum and fascia with a simple continuous suture of catgut.

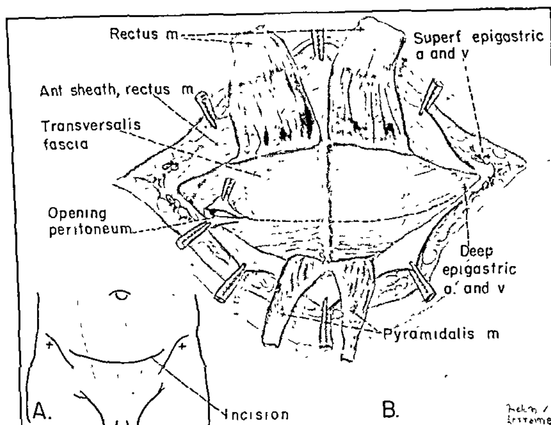



Fig 557.—Cherney incision for operation on lower abdomen.

The muscles are not approximated after transverse division, since it is technically almost impossible to do, and, besides, it is not necessary for a firm closure. Split flat muscles, such as the external and internal oblique and transversus abdominis, are loosely approximated with interrupted sutures of cotton or silk. It is usually not necessary to suture the rectus muscle after splitting, since closure of the sheath and the natural contraction of the muscle results in good approximation.

The fascial layers are carefully approximated with interrupted sutures of cotton or silk placed as simple or figure-of-eight sutures (Fig. 558, *B*). Cotton is preferred, since the tissues seem to tolerate it better in case of infection. Some surgeons prefer stainless steel wire, but there are no particular advantages to compensate for the difficulty in the handling of it.

The subcutaneous tissue and superficial fascia are closed with interrupted sutures of fine cotton, No. 60, or 000 silk. Fine catgut can be used. The skin is finally closed with continuous, simple, or on-end mattress interrupted sutures (Fig.

558, *C*) of cotton or silk. A firm pressure dressing is then applied. This is not removed until time for removal of the skin sutures unless drains have been used or it is necessary to check the incision for infection because of unexplained fever or local discomfort.

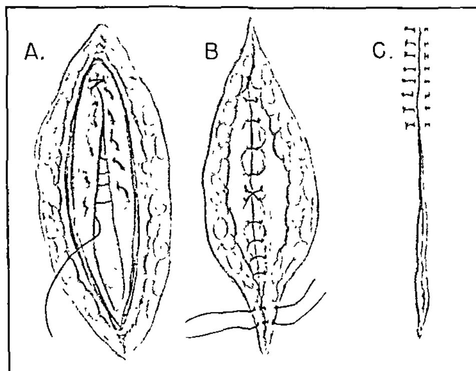



Fig 558 —Closures of abdominal incisions.

Retention sutures are preferred by some surgeons for routine closures and by all under certain unusual circumstances. If applied correctly, they obliterate all dead space and relieve the tension on the finer sutures.

## MANAGEMENT OF CONTAMINATED WOUNDS AND DRAINAGE METHODS

There is considerable disagreement as to the management of abdominal incisions in the face of gross contamination of the wound surfaces by flora from the gastrointestinal tract. Since infection is tolerated least well by the subcutaneous tissue, the skin and subcutaneous tissue should be left open and the other layers closed as usual. Some surgeons prefer to use stainless steel wire in contaminated wounds, and others use catgut, but silk sutures are not used. Cotton is tolerated fairly well in contaminated wounds and is used occasionally under these conditions

In case of gross contamination, as occurs in generalized peritonitis, the peritoneum is closed with catgut and the fascial layers are sutured with interrupted cotton, but the subcutaneous tissue and skin are left open. Simple sutures, including the subcutaneous tissue and skin, are placed, however, and fine mesh gauze is laid in the wound The wound edges are approximated on the fourth postoperative day by tying the previously placed sutures If there is questionable contamination of the wound, the incision may be closed as usual, except that the subcutaneous tissue and skin are loosely approximated and rubber drains are placed down to the

fascia at each wound angle. After intestinal resection with either open or closed anastomoses, the incisions are closed as in other clean elective surgery. Sulfonamides and antibiotics are not used locally, since there is considerable doubt as to their value when used topically.

Drains or tubes are brought out through stab wounds separate from the incision, if possible. This allows careful approximation of the entire length of the incision, layer by layer, and results in a stronger incision. The incision may become infected when the drainage tube is brought through it and disruption may result. Drains should be placed at the most dependent point and as far laterally as possible.

## WOUND SEPARATION AND EVISCERATION

The cause of separation of wound edges may not always be clear, but it is usually due to one or a combination of a number of factors which may be grouped as anatomic, local, and general. Good surgical technic and pre- and postoperative care have as their object the elimination of as many of these as possible.

Anatomically, wound separation more frequently occurs in vertical upper abdominal incisions. This incision is subjected to an abnormal lateral pull because the attachment of the flat muscles make up the rectus sheath. Coughing or vomiting places a great strain in a direction perpendicular to the line of the incision. Transverse and lower abdominal vertical incisions are not subjected to as great a strain.

A number of local factors may contribute to wound separation. The first of these is failure to obtain a careful layer by layer closure of the incision. A most important part of the closure is the approximating of the peritoneum and also of the posterior rectus sheath where it is present, although the importance of this is often not appreciated. As described in the technic of closure of incisions, the peritoneum is so closed that the posterior rectus sheath, when present, can be approximated with interrupted sutures of cotton or silk. If a defect is present in the peritoneum and posterior rectus sheath, this may be the opening wedge for the omentum or a loop of intestine to push through all the layers of the incision. Although wound separation occurs regardless of suture material, less reaction results when cotton or silk is used. Catgut may rapidly absorb in some wounds, possibly because of allergic sensitivity. Hematoma formation in a wound may be a factor in wound separation. Absolute hemostasis is, therefore, most important. Wound infection often is a cause of wound separation Infected wounds should be carefully watched, and adequate drainage should be instituted to prevent further extension of the infection by dissection. The bringing of drains through the incision may be a factor in the development of infection in the incision, or the defect resulting after removal of the drain could be the entering wedge that finally results in complete separation.

Wound separation most commonly occurs in elderly patients with carcinoma. These patients are often dehydrated, suffer from hypoproteinemia, avitaminosis (particularly vitamin C), and anemia. Any of these factors may be responsible for delayed wound healing. Abdominal distention, coughing, or vomiting may precipitate wound separation if healing has been delayed by any of the factors mentioned.

The incidence of wound separation and evisceration will be kept at a minimum by adherence to the following principles:

1. Careful preoperative preparation to correct dehydration, hypoproteinemia, anemia, and avitaminosis.

2. Prevention of reaction and infection in wound by meticulous handling of tissues, inclusion of as small a volume of tissue in ties as possible, minimal use of the electrosurgical unit to control bleeding, absolute hemostasis, and careful layer by layer approximation and obliteration of dead space, preferably using interrupted cotton sutures or silk, with the exception of continuous catgut for the peritoneum.

3. Bringing of drains through stab wounds, rather than through the incision.

4. Prevention of chest complications.

5. Control of abdominal distention by judicious use of smooth-muscle-stimulating drugs and gastrointestinal drainage by suction.

Wound separation should be suspected if the dressing and bedclothes suddenly become soaked with serosanguineous fluid. The wound should be checked immediately. Separation occurs most frequently following removal of the skin suture. If separation alone has occurred, the wound edges are strapped together with wide strips of adhesive until preparations are made to resuture the incision. If evisceration has also occurred, the loops of bowel are reduced and held in place with a sterile towel until the wound can be resutured.

## CLOSURE OF DISRUPTED WOUND

It is usually impossible to resuture the wound layer by layer because of the friability of the tissues. Sutures of heavy braided silk or monofilament nylon are placed through all layers of the abdominal wall. The sutures can be placed under local anesthesia if the patient's condition is poor. One end of the suture is threaded on a large curved needle and is brought through the abdominal wall on one side from within out to prevent the accidental perforation of a loop of bowel. The other end is then threaded on a curved needle and brought through the opposite side of the abdominal wall from within out. A short piece of rubber tubing is threaded on each suture and the sutures are tied.

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# CHAPTER 47

# ACUTE CONDITIONS OF THE ABDOMEN

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Early diagnosis and successful operation for various acute lesions of the abdomen are among the most important and essential factors in reducing the mortality from these conditions. No situation in surgery requires more skillful judgment and appraisal of facts than does abdominal pain In the acute surgical abdomen an accurate history, a complete physical examination, and the employment of the indicated laboratory examinations all play equally important roles in making the correct diagnosis. *Nowhere in surgery is accurate diagnosis of more importance than in a patient with the complaint of abdominal pain, and keen surgical judgment must be employed to determine when not to operate as well as when to operate.*

The origin of abdominal pain is quite complex, and it is important to have a thorough understanding of the mechanism for visceral pain. Pain arising from different levels in the gastrointestinal tract ordinarily can be localized to particular segments of the abdominal wall. For instance, cramps in the epigastric or upper abdominal regions usually arise from the small bowel, gall bladder, and stomach. The familiar cramps of a gastroenteritis are localized to the epigastric and periumbilical regions. Colonic pain, on the other hand, is generally localized in the lower abdomen and suprapubic regions. Finally, pain arising from the lower sigmoid and rectum is often reflected in perineal and sacral pain.

The character of abdominal pain is of importance in arriving at an accurate diagnosis. Knowing whether the pain is steady or intermittent, sharp or aching is of great help in determining its origin. The localization and radiation of abdominal pain must be carefully investigated. In association with abdominal pain the presence of vomiting, diarrhea, constipation, or the passage of blood is of first importance. Whether or not the patient has had chills or fever should be ascertained. These points in the history all are carefully appraised in making the diagnosis.

In the physical examination of the patient complaining of abdominal pain, it is particularly important to note any abdominal distention, muscle spasm, abdominal tenderness, and the presence of palpable masses or organs. The character of peristaltic sounds and the presence or absence of intraperitoneal fluid must be determined. The presence or absence of inguinal and femoral hernia should be noted in recording the physical findings. Digital examination of the rectum is often forgotten and should always be employed in diagnosing abdominal pain. Finally, the presence of skin rashes or pulmonary pathology is given careful consideration.

Laboratory examinations of importance include the usual routine complete blood count and urinalysis and, in addition, may include x-ray examination and various studies of the blood chemistries.

Only after all these facts are marshalled together can the examiner accurately make the diagnosis and prescribe the proper treatment.

## CONDITIONS SIMULATING ABDOMINAL EMERGENCIES

In evaluating a patient with an acute abdominal complaint, it must be borne in mind that disorders of other than intra-abdominal organs may lead to complaints simulating abdominal emergencies. All of these conditions should be kept in mind in appraising the patient complaining of abdominal pain. Some of these allied disorders which may lead to confusion with abdominal emergencies will be discussed briefly.

It is well known that intrathoracic pathology of one sort or another may produce abdominal symptoms. For instance, pneumonia in the right lower lobe may lead to severe abdominal pain and spasm of the muscles of the right upper abdominal quadrant. Pulmonary infarction may simulate an upper abdominal emergency. The referred pain from pleurisy often leads to confusion in diagnosis. The history and physical examination, together with an x-ray of the chest, should be enough to differentiate intrathoracic infections or other conditions simulating abdominal emergencies.

Arteriosclerotic heart disease with acute myocardial infarction sometimes is confused with acute cholecystitis or other upper abdominal conditions. Here again physical examination, accurate recording of historical details, and the employment of suitable x-ray and other laboratory means are essential in arriving at the correct diagnosis.

One condition which is prone to be confused with appendicitis or other lower abdominal emergencies is renal colic. Where the stone is lodged in the ureter, the pain may be entirely abdominal and may not radiate from the flank to the groin as it usually does. The differential diagnosis between an abdominal emergency and renal colic is often difficult but is more easily made when the classical radiating pain is present and when blood is found in the urine. It must be remembered, however, that acute appendicitis may be accompanied by blood and pus in the urine when the inflammation involves the adjacent ureter.

Another common cause for abdominal pain which is often confused with surgical emergencies is gastroenteritis Here the presence of fever, leukocytosis, generalized abdominal pain and tenderness, and the picture of prostration may make the proper diagnosis very difficult. On the other hand, the history of vomiting or diarrhea coupled with the absence of localized abdominal signs enables one in general to arrive at the correct diagnosis.

A very common cause of abdominal pain in children and young adults is mesenteric lymphadenitis. This condition, of course, is purely medical, but it is often confused with appendicitis when the iliac nodes are inflamed. There is no suitable method of differentiating between iliac lymphadenitis and acute appendicitis, and in many cases it is safer to operate for appendicitis even though the impression is that the child is suffering from a mesenteric adenitis. In this connection it may be well to mention the recently reported discovery of histoplasmosis of the

appendix as a cause for appendicitis and regional lymphadenitis. This work was carried out at the Henry Ford Hospital in Detroit, Michigan, and is of interest particularly in the geographical areas where histoplasmosis is more prevalent.

Herpes zoster (shingles) and intercostal neuralgia sometimes cause radiating pain localized to one side of the abdomen, and this may be indistinguishable from pain which is visceral in origin.

A less common cause of abdominal pain is tabes dorsalis; the gastric crisis of this disease produces severe abdominal symptoms. Syphilis is much less prevalent now than formerly, and the development of tertiary syphilis is uncommon.

Rheumatic fever is sometimes accompanied by vague abdominal pains, and these must be carefully appraised in children before operation is undertaken. Similar pains are sometimes found in poliomyelitis.

Occasionally a young person who has indulged in strenuous activity in very hot weather may be prostrated with severe abdominal cramps. These muscular cramps are spoken of as "heat cramps" and respond well to the intravenous injection of saline.

Dissecting aortic aneurism or saccular aneurism of the aorta may produce abdominal pain in association with the characteristic back pain. The pain in these conditions is usually due to stretching of the wall of the aorta and pressure on nerve roots, and severe acute pain may accompany rupture or dissection.

Retroperitoneal tumors may cause abdominal pain from pressure of increased growth and, particularly, when a mass is palpable may lead to confusion in diagnosis

Many other less common conditions may cause confusion in diagnosis, and a careful weighing of all the evidence at hand is essential in arriving at a correct diagnosis.

## DIFFERENTIAL DIAGNOSIS

The differential diagnosis of the many conditions in the abdomen which lead to surgical emergencies calls for the finest judgment on the part of the examining surgeon. The sequence of events in the development of abdominal symptoms is of great importance. As mentioned before, the character of the pain and radiation of it must be carefully evaluated. Accompanying fever and chills are points of importance as are the presence or absence of jaundice and cyanosis. It is essential to determine the presence of preexisting hernia, and, when intestinal obstruction is suspected, the character of vomiting and the passage of flatus must be ascertained. Change in the character or regularity of bowel movements, loss of weight, and history of previous attacks should be investigated. In short, an accurate and detailed account of the patient's present illness and pertinent past history is essential in arriving at the correct diagnosis.

On physical examination the vital signs are of great importance, and the patient's general appearance must be carefully weighed. In addition to a complete general physical examination, careful attention to a detailed abdominal examination is in order Two things in the examination of the abdomen which often are overlooked are investigation for the presence of inguinal and femoral hernia and digital examination of the rectum. These two studies are as much a part of examination of the abdomen as is percussion or auscultation. Auscultation of the ab-

domen is of great value. The presence or absence of peristaltic sounds and the character of abnormal sounds are helpful in studying each patient. For example paralytic ileus ordinarily is accompanied by a quiet abdomen, while in mechanical bowel obstruction the peristalsis is hyperactive and high-pitched.

From the standpoint of the laboratory examinations, in addition to the usual blood counts and urinalysis the following laboratory tests are frequently employed. First, x-ray examination of the abdomen is of particular importance in intestinal obstruction or in an effort to locate calculi or foreign bodies. Second, various blood chemistries such as nonprotein nitrogen, serum amylase, serum bilirubin, carbon dioxide combining power, serum chloride, etc., may be of the utmost importance in differentiating causes of abdominal pain.

In summary, the differential diagnosis of the various acute conditions of the abdomen is a matter requiring fine judgment and complete study. Many conditions in the abdomen require immediate intervention surgically, and still others are best treated by nonsurgical means In the rest of this chapter individual acute conditions of the abdomen will be discussed and the means for arriving at the correct diagnosis and proper treatment stressed

## ACUTE APPENDICITIS

The most common acute condition of the abdomen requiring surgical intervention is acute appendicitis, and this must be borne in mind whenever the cause of the so-called "acute abdomen" is not obvious. The most severe abdominal pains occurring in patients who have been previously well and persisting for several hours are caused by conditions of surgical import, and appendicitis is the condition most often responsible. It is essential in appendicitis to arrive at the diagnosis early and to carry out the operation before perforation has occurred.

Because the appendix is not a fixed structure, the symptoms and signs of acute appendicitis are variable; however, the classical picture and the one most often encountered is that of abdominal pain beginning in the epigastric or periumbilical region and later shifting to the right lower quadrant. Shortly after the onset of pain, nausea and vomiting are likely to ensue. It is then that shifting of pain to the right lower quadrant becomes of utmost significance. The patient often feels the desire to have a bowel movement and attempts to evacuate sometimes unsuccessfully, or, if successfully, without relief of pain. It is common knowledge among lay people at the present time that appendicitis if neglected is a serious disease, and usually after the persistence of pain or the failure of a bowel movement to relieve the pain, the patient seeks medical advice When one obtains the history of generalized abdominal pain localizing subsequently in the right lower quadrant, the diagnosis of appendicitis must be strongly suspected. Since the location of pain in appendicitis is affected by the position of the appendix, there may be variations from the classical picture. A retrocecal appendix may give rise to flank pain and tenderness, while a low-lying pelvic appendix often causes pelvic pain and symptoms of urinary tract or adnexal disease.

On physical examination there usually is a low-grade fever and slight tachycardia, and classically there is deep tenderness in the right lower quadrant near McBurney's point. Muscle spasm is a late finding, and should not be relied upon, but

when present it is of great importance. Rectal examination is sometimes of value in localizing tenderness on the right side of the pelvis. Peristaltic sounds are usually suppressed and may be absent if perforation has occurred.

Leukocytosis is commonly present, but there is usually no other significant abnormality in the laboratory examination. In approximately 15 per cent, there is a normal total leukocyte count, but an increased polymorphonuclear count is important.

Once the diagnosis of acute appendicitis has been made, the proper treatment is appendectomy. An appendectomy is most advantageously performed through a McBurney incision except in unusual cases. In young females where the diagnosis is somewhat in doubt, it may be of more importance to have a larger incision, such as a right paramedian approach, so that the pelvis or the rest of the peritoneal cavity can be explored. Certainly the McBurney incision has many advantages, among which are the ease of its accomplishment, the relative lack of postoperative pain, and the convenience of this approach for drainage in cases where abscess is encountered. During the course of the operation, if the appendix appears to be normal, further exploration should be carried out, particularly searching for mesenteric lymphadenopathy, regional enteritis, Meckel's diverticulum, adnexal disease, and so forth. A prophylactic appendectomy should be performed even though the appendix appears normal, except when this procedure is specifically contraindicated (such as in tuberculosis of the ileum or cecum, or in regional enteritis). The method of treatment of the appendiceal stump is a matter of controversy and is discussed further in the chapter on Appendectomy. Treatment of ruptured appendicitis with generalized peritonitis or abscess is discussed in the chapter on Peritonitis and in the chapter on Appendectomy.

Prompt diagnosis and early operation together with the judicious use of modern antibiotics have reduced the mortality rate in appendicitis appreciably. Acute appendicitis is still the most common and the most difficult to diagnose of all acute abdominal emergencies, and it must always be kept in mind when abdominal pain occurs.

## ACUTE CHOLECYSTITIS

The gall bladder, being a hollow, distensible organ subject to obstruction at its neck, is often the source of abdominal pain. Gall stones may reside asymptomatically in the lumen of the gall bladder, but if one becomes impacted in the cystic duct, biliary colic will develop. In older people acute cholecystitis is frequently the cause of severe attacks of abdominal pain. Because of the associated nausea and vomiting usually present in the early stages of biliary colic, gastritis, appendicitis, and intestinal obstruction are frequently considered as the primary diagnosis.

The diagnosis of acute cholecystitis is usually made when the pain is localized in the right upper abdominal quadrant and is accompanied by rather profound prostration and vomiting. In older people it is often possible to palpate the distended gall bladder, thereby adding security to the diagnosis. It is often difficult to distinguish between acute appendicitis and acute cholecystitis in the early stages.

If the diagnosis of acute cholecystitis has been made, a decision must be made as to whether this condition should be treated surgically or expectantly. The con-

sensus at the present time is that immediate operation with removal of the acutely inflamed gall bladder where possible is the treatment of choice in the first seventy-two hours of the patient's illness. During the first three days it is often difficult to determine the stage of the pathologic process in the gall bladder, and gangrenous cholecystitis with rupture of the gall bladder may occur. If there is no perforation of the gall bladder, the acute inflammatory process usually subsides, but a mass of dense fibrous tissue and adhesions commonly follows healing. On the other hand, during the stage of edema and acute inflammation in the wall of the gall bladder, it is often technically very simple to remove this organ, and this is the operation of choice in the early stage. Following the first three days it is probably better to treat the patient expectantly unless complications arise and then to remove the gall bladder electively at a later date. If expectant treatment is pursued, there are certain specific indications for abandoning this course and resorting to operation. These are increasing temperature, pulse rate, and leukocyte count, progressively severe pain, shock, further enlargement of the gall bladder, and failure to improve after a reasonable period of observation.

Immediate surgical intervention for acute cholecystitis has always been a subject fraught with controversy, and it is likely that this will continue to be so. The underlying etiologic process in acute cholecystitis is obstruction of the cystic duct by a small calculus. The internal pressure in the gall bladder is then gradually raised until there has been thrombosis of the vessels in the wall of the gall bladder, leading to ischemia, acute inflammation, and possibly to necrosis. Because it is uncertain whether rupture or healing will occur at this stage, it seems wiser to remove the gall bladder rather than to run the risk of rupture. In this respect cholecystitis is treated as is appendicitis. On the other hand, many patients with acute cholecystitis are not seriously ill, and many of these can be treated expectantly. When a patient has once had acute cholecystitis, it is imperative when feasible to remove the gall bladder at a later date if conservative treatment is pursued during the acute attack.

If operation is attempted and the patient's condition does not justify cholecystectomy, the procedure of cholecystostomy is substituted and the drainage tube is left in place for ten to fourteen days. When cholecystostomy is carried out, again cholecystectomy is advised after a suitable convalescent period.

Obviously the mortality rate in acute cholecystitis is far greater than that when operation is employed for chronic cholecystitis; however, if good clinical judgment is used and the patient's water balance and electrolytes are maintained at normal levels and infection is kept to a minimum with antibiotics, the mortality rate in acute cholecystitis treated operatively should compare favorably with that for acute appendicitis.

## PERFORATED PEPTIC ULCER

Sudden perforation of a peptic ulcer produces one of the most dramatic and agonizing acute conditions in the abdomen It is often stated that less than 25 per cent of the patients with acute perforations of peptic ulcers have previous ulcer symptoms, but it is believed that if a careful history were obtained, nearly all of the patients coming to operation for acutely perforated peptic ulcer would give some history suggesting previous disorder These symptoms may not be the classical symptoms of peptic ulcer but usually are those of indigestion or abdominal pain.

Classically acute perforation of a peptic ulcer is accompanied by the sudden onset of severe, sharp upper abdominal pain, causing the patient to double up. The pain rapidly spreads from the site of origin so that it occupies the upper half of the abdomen or indeed the entire abdomen. Due to the irritation of the peritoneum from the gastric contents, there is intense muscle spasm, producing so-called board-like rigidity. When gas escapes into the peritoneal cavity along with the gastric juices, there may be diaphragmatic irritation leading to pain in the shoulders, and it is often possible to demonstrate obliteration of liver dullness on physical examination. Upright and lateral decubitus films of the abdomen will often reveal the presence of small amounts of free air.

The usual differential diagnosis lies between acute pancreatitis, acute cholecystitis, and perforation of a peptic ulcer, and the exact diagnosis may be difficult to make.

When the diagnosis of perforated ulcer has been made, it is felt that the treatment should always be surgical although the British and others treat perforated ulcers by continuous gastric suction and antibiotics One can never feel certain that the perforation is being sealed over. Many times, even in the absence of free air under the diaphragm, at operation a perforated ulcer measuring larger than 1 cm. in diameter has been found, and it is hardly conceivable that this type of ulcer would be sealed over merely by keeping the stomach empty. The operation of choice is simple closure of the perforation, but in some instances subtotal gastrectomy may be desirable.

The operation itself is best accomplished through a vertical incision in the upper abdomen, and the ulcer is usually closed with interrupted sutures. Whenever the ulcer is on the stomach side of the pylorus, an attempt is made to biopsy the lesion in order to rule out carcinoma.

Operative treatment of perforated ulcer gives gratifying results, and it is remarkable how the abdominal findings change within a few hours after operation.

## ACUTE PANCREATITIS

The diagnosis of acute pancreatitis is best made by the finding of an elevated serum amylase, but since this occurs usually in the very early stages of this process, the finding of a normal value is not of diagnostic importance. Acute pancreatitis is said to occur almost exclusively in persons who have been drinking alcohol of one sort or another. Classically the pain begins in the upper abdomen and radiates to the left flank. The disease is often accompanied by profound shock, cyanosis, and extreme prostration. This is particularly true of the necrotizing hemorrhagic type of pancreatitis, and in the milder forms prostration may not be a prominent feature. Because of the nature of the disease, medical treatment is to be preferred. Recent advances in the medical treatment of pancreatitis include splanchnic block and epidural procaine block with a catheter inserted into this space and advanced to the mid-thoracic region Spectacular relief of pain and signs of pancreatitis have been reported following these procedures. On the other hand, if there is doubt as to the correct diagnosis, and exploration is carried out, operative treatment can be of considerable value.

One theory of the etiology of pancreatitis presupposes a common drainage duct for the pancreas and the common bile duct, and it is postulated that small gallstones

may pass into the pancreatic duct and thus cause obstruction and resulting pancreatitis. If this be true, the common bile duct or at least the gall bladder should be drained in all cases of acute pancreatitis treated surgically. In addition, there is often an accumulation of fluid in the lesser peritoneal cavity, and this can be drained by inserting drainage tubes through the foramen of Winslow and through the gastrocolic and/or gastrohepatic ligaments. Whipple advocated the insertion of large rubber drains into the body of the pancreas itself in order to relieve the tension within the pancreatic capsule. Supportive measures together with the operation include the administration of large amounts of calcium to replace that which is lost in an effort to bind the fatty acid released by the necrosing process in the pancreas, the replacement of a large amount of fluid which is lost intraperitoneally and by sweating, and the use of antibiotics.

Pancreatitis is a difficult disease to diagnose and a more difficult one to treat, and the mortality rate is still considerable. If the diagnosis is made by the finding of an elevated serum amylase, it is better to pursue a medical course of treatment unless surgical intervention is indicated by unfavorable progress of the patient.

## INTESTINAL OBSTRUCTION

Acute obstruction of the intestine due to adhesions, incarcerated hernia, volvulus, or the like is one of the most serious causes of abdominal pain and one which requires prompt and skillful treatment. Whereas obstruction of the large bowel may cause abdominal pain followed only after a considerable lag by vomiting and prostration, small intestinal obstruction causes early prostration and produces more definitive symptomatology. Obstruction of the small bowel is most commonly caused by postoperative adhesions leading to kinking of the intestine, by incarceration of the bowel in an external or internal hernia, by intussusception, etc. Large bowel obstruction, on the other hand, is most commonly caused by carcinoma, volvulus, or acute and chronic inflammation (such as diverticulitis). Early treatment is most essential in intestinal obstruction.

The usual symptomatology is that of the sudden development of abdominal cramps followed by distention, and the failure to pass flatus. Vomiting is a common and early feature of small bowel obstruction but occurs later in large bowel obstruction The nature of the vomitus is characteristic, and in many cases the gastric contents are fecal in nature. Prolonged vomiting leads to dehydration, electrolyte imbalance, and often to shock.

On examination the presence of distention and the character of peristaltic sounds are of great importance. Diligent examination for hernia or for other cause of obstruction should be made. The diagnosis is substantiated by x-ray examination by the finding in upright films of dilated loops of intestine with fluid levels.

In large bowel obstruction if the obstruction is complete, decompression is usually accomplished by cecostomy or proximal colostomy. The technic of these operations is described elsewhere. After suitable deflation of the large bowel has been accomplished, definitive surgery may be undertaken to relieve the cause of the obstruction.

On the other hand, small bowel obstruction is often treated nonoperatively by the use of intestinal suction with a Miller-Abbott or similar type of tube. This

method of treatment is to be preferred in acute obstruction in recent postoperative patients. Contrariwise, the prolonged and indiscriminate use of intestinal suction for deflation of the small bowel may lead to disastrous results, especially in incarcerated hernias or obstruction due to tight adhesive bands. For this reason it is best to treat almost all cases of small intestinal obstruction by immediate operation and supplement the surgical treatment with Miller-Abbott tube suction.

Before operation is attempted in patients with obstruction, the dehydration and electrolyte disturbance should be corrected by appropriate intravenous administration of fluid and electrolytes. If shock is present, blood transfusions are used freely. When gangrene of the bowel is found at operation and resection of the intestine is necessary, the mortality rate rises sharply. The technic of intestinal resection is given elsewhere.

The studies of Noer, Derr, and Johnston have convincingly demonstrated the importance of early relief from distention in the intestine. For this reason early operation is imperative and must be carried out in competent hands. Decompression of the obstructed bowel by surgical aspiration is indicated when great distention is present.

## VISCERAL INJURIES

Injuries to intra-abdominal viscera present problems of management rather than of diagnosis in the majority of cases, since the external evidence of injury is usually present. Gunshot and stab wounds of the abdomen necessarily call for exploration as soon as possible. Many patients who have been stabbed or shot come to the emergency room in a grave condition, and the shock must first be combated; however, if it is obvious that there has been or is major blood loss, it may not be possible fully to correct the shock prior to operation. In many cases it is possible to diagnose an injury to a major blood vessel requiring immediate laparotomy and rapid infusion of blood during the operation; however, to delay operation while treating shock may be a fatal maneuver since it is imperative to stop the source of bleeding as soon after the injury as possible. Any patient suffering from a single gunshot wound of fairly large caliber or from multiple such wounds or from stab wounds apparently entering the peritoneal cavity should be operated upon immediately and the injuries repaired; however, in shotgun wounds of the abdomen where the pattern is diffuse and where it is likely that many tiny perforations of the abdominal viscera have occurred, it is wiser to treat the patient expectantly. Small pellets even though they penetrate the bowel often cause a prolapse of the mucosa that will plug the perforation and prevent soiling. In larger wounds, however, and in shotgun wounds with a small pattern from close range firing, operation should be done as promptly as possible in order to repair the inevitable visceral damage.

The surgical treatment of gunshot and stab wounds of the abdomen depends upon the type of injury found at exploration. If there are through-and-through wounds or penetrating wounds of the gastrointestinal tract, these must be closed in a suitable fashion. If there is damage to the mesentery or to a large segment of the bowel, resection and anastomosis may be indicated. Very frequently in gunshot and penetrating stab wounds of the abdomen, blood loss is *considerable*, due to injury of a large mesenteric vessel or to the aorta or vena cava. Whenever a major blood vessel such as the aorta or one of its branches has been damaged, an attempt should

may pass into the pancreatic duct and thus cause obstruction and resulting pancreatitis. If this be true, the common bile duct or at least the gall bladder should be drained in all cases of acute pancreatitis treated surgically. In addition, there is often an accumulation of fluid in the lesser peritoneal cavity, and this can be drained by inserting drainage tubes through the foramen of Winslow and through the gastrocolic and/or gastrohepatic ligaments. Whipple advocated the insertion of large rubber drains into the body of the pancreas itself in order to relieve the tension within the pancreatic capsule. Supportive measures together with the operation include the administration of large amounts of calcium to replace that which is lost in an effort to bind the fatty acid released by the necrosing process in the pancreas, the replacement of a large amount of fluid which is lost intraperitoneally and by sweating, and the use of antibiotics.

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first be made to preserve this vessel by suture of the wound. It is always advisable to have at hand small bulldog clamps and arterial sutures for such an event. If, however, it is impossible to save the vessel by suture of the wound, it may be necessary to ligate both ends of the injured vessel. In the case of injuries to the vena cava or aorta every effort should be made to preserve their continuity. If one of the iliac arteries has to be sacrificed, it would seem advisable to perform a lumbar sympathectomy at the time of the exploratory laparotomy if the patient's condition permits; this procedure may forestall development of ischemia in the lower extremity. Ligation of large mesenteric vessels may lead to gangrene of the corresponding segment of bowel, and this must be borne in mind.

Wounds involving the liver, spleen, or kidneys must be treated accordingly, although the spleen may be removed with impunity. Large fracturing wounds of the liver are probably best treated by the insertion of hemostatic sponges of oxidized cellulose or gelatin foam and suturing with large catgut sutures. If this is impractical, it may be necessary to pack the liver with gauze rolls in order to stop hemorrhage. Fragments and traumatized edges of liver substance should be removed, as, if left, they will become necrotic and produce complications. Wounds of the kidneys must be treated with caution. If one kidney is damaged, it is important at the time of laparotomy to determine the presence of the contralateral kidney. Every effort should be made to save the injured kidney, and it has been recommended that the hemorrhage be controlled by tight packing and that nephrectomy be postponed until several days after the initial operation, in order, first of all, to avoid the trauma of such a procedure and, second, to ascertain the functional capacity of the other kidney. Wounds of the ureters may be treated by suturing and the insertion of ureterocutaneous catheters. Injuries to the bladder and pelvic viscera are treated as seems best at the time of exploration, and the bladder should always be decompressed by the insertion of a Foley catheter and also by suprapubic cystotomy.

Wounds of the colon are usually not difficult to handle unless the rectum is injured by a gunshot wound in the extraperitoneal region where exposure is difficult. In multiple wounds of the colon, or where the closure of these wounds does not appear entirely satisfactory, or where the blood supply is questionable, the value of a proximal colostomy cannot be stressed too greatly. A temporary colostomy is an annoyance to the patient, but may be a lifesaving measure and takes only a few minutes to perform at the time of exploration. A loop colostomy in the transverse or descending colon is the simplest procedure and one which affords almost complete diversion of the fecal stream It should be maintained as long as there is any danger of infection or poor healing distal to it and may be closed electively at a future date. When the blood supply to the colon is seriously impaired, resection of the colon involved can be performed. When the patient's condition is poor, exteriorization of the injured colon or of the two ends of the bowel after resection may be advisable.

Although the diagnosis of gunshot or stab wound of the abdomen is self-evident, severe blunt force injury of the abdomen may lead to serious intraperitoneal damage which might pass unrecognized Patients receiving sudden severe blows to the abdomen, such as a kick by an animal or a fall on a blunt object, should be observed most carefully Retroperitoneal hematomas, tearing injuries of the mesentery or bowel, and serious injury to the kidneys, liver, or spleen may result from blunt force injuries. The damage results from force applied to the viscus against the ver-

tebral column. Any patient receiving such a blunt force injury who shows signs of shock, peritoneal irritation, or obvious blood loss should be explored just as with a penetrating wound from gunshot or stabbing injuries. The importance of close observation of patients with blunt force injuries of the abdominal wall cannot be stressed too strongly. In such patients, again, the type of treatment depends upon the situation which is found at operation.

Since most patients with injuries to the intra-abdominal viscera as a result of penetrating or blunt force wounds suffer some degree of shock, the liberal administration of whole blood transfusions and intravenous fluids is stressed. Antibiotics are given to forestall or to treat infection which may result from such injuries. It is often a wise policy to perform a phlebotomy on the greater saphenous vein at the ankle and to insert a Horsley cannula for rapid administration of blood should a severe injury to a major blood vessel be encountered. This takes but a few minutes before the operation is begun and may be the factor in preserving the patient's life. In all cases of injury to the gastrointestinal tract Wangensteen suction should be employed postoperatively and indeed the diagnosis of penetrating injuries to the stomach can be made often by the insertion of a Levine tube and aspiration of blood.

For further description of handling gastrointestinal wounds, see chapters on operations on the intestines and colon.

## GYNECOLOGIC AND OBSTETRIC CONDITIONS

In the differential diagnosis of acute surgical conditions of the abdomen many gynecologic and obstetric conditions should be considered in female patients. Some of these are torsion or rupture of an ovarian cyst, torsion of a pedunculated fibroid tumor, tubo-ovarian abscess, ruptured graafian follicle with hemorrhage, ectopic gestation with bleeding or actual rupture, and many others Salpingitis is frequently confused with appendicitis and tubo-ovarian abscess with appendiceal abscess. It goes without saying that a careful pelvic examination is an integral part of the examination for acute surgical abdomens in women. If twisting or rupture of an ovarian cyst is suspected, immediate laparotomy is indicated. The same is true for torsion of a pedunculated fibroid. Tubo-ovarian abscesses often must be drained by an abdominal approach but, if possible, are best drained by colpotomy. This procedure should never be carried out unless there is actual pointing of the abscess in the posterior fornix. Bleeding ectopic pregnancy should always be considered in young women in whom there is a sequence of some irregularity of menstrual history, slight vaginal bleeding (often not present), anemia, and the finding of a soft tender mass in the adnexal region. Often when phlebotomy is performed for initial blood counts, it is noted that the blood is very thin, and this may be the tip-off as to the diagnosis. It is urgent to operate as early as possible on all ectopic pregnancies. The technic of operation for ovarian cyst, ectopic pregnancy, and other gynecologic and obstetric conditions is discussed in the chapters on gynecology.

## ABDOMINAL APOPLEXY

The unusual condition of massive intraperitoneal hemorrhage without obvious source is sometimes encountered in emergency patients. It creates a most unsatisfactory feeling in the surgeon's mind to perform a laparotomy for abdominal pain and find the peritoneal cavity filled with large amounts of free blood for which no

obvious source can be found. One explanation has been that the bleeding occurred through the open fimbriated end of the fallopian tube. Another has been that there has been rupture of a small mesenteric vessel. However, there is no satisfactory explanation for this situation. It is treated simply by aspiration of the blood and thorough search for a source, but, if none be found, the wound is closed and the patient is treated expectantly.

## MISCELLANEOUS CONDITIONS

There are many other causes for acute abdominal pain which enter into the differential diagnosis and which are encountered as the source of pain when laparotomy is performed. All of these diseases and disorders cannot be fully discussed, but several will be mentioned briefly here.

Mesenteric thrombosis presents one of the most discouraging and most challenging situations encountered in emergency surgery. Occlusion of the major arterial supply to the small bowel may occur from embolism in a patient with arteriosclerotic heart disease with fibrillation, but more often than not the etiology of such a condition is unknown. The onset of the patient's illness is sudden, and the immediate symptoms are severe. There is great prostration and there are signs of intestinal obstruction. When the entire superior mesenteric artery has become occluded, there is a characteristic picture in the flat x-ray of the abdomen revealing gas in the entire small bowel and in the large bowel to the splenic flexure. The finding of such a picture may be of considerable value in diagnosis. If mesenteric vascular occlusion is found at operation and the extent is very severe, there may be such extensive involvement of the bowel as to contraindicate resection. In such patients the use of heparin and other anticoagulants is indicated, and occasionally a patient with apparent gangrene of large segments of the bowel due to mesenteric occlusion recovers, even after operation when no resection was carried out because of the apparent hopelessness of the situation. Venous mesenteric occlusion appears to be of a more serious nature than arterial mesenteric thrombosis. Retrograde propagation of the clot in venous thrombosis is common and the extent of involvement is often more complete than in arterial occlusion. If localized resection of the bowel appears to be feasible, this is performed, and, if possible, the mesenteric veins are ligated above the clot. Simultaneous use of anticoagulant therapy is also of great value.

Volvulus of the intestine is to be considered in all cases of intestinal obstruction. Volvulus of the small bowel in association with congenital malformations of the bowel is unusual and must be treated by detorsion at operation and resection if gangrene has set in. Of much more importance and of much more frequent occurrence is volvulus of the sigmoid colon. This is ordinarily a chronic condition with acute exacerbations and presents a very characteristic picture. There is enormous distention of the abdomen with visible peristalsis and a considerable amount of pain, accompanied by vomiting later in the stages of the illness The diagnosis is made by the recurrence of such a picture The x-ray picture in the advanced case of sigmoid volvulus is characteristic, with huge distention of the sigmoid loop and a spadelike deformity at the point of obstruction demonstrated by barium enema. Sometimes a rectal tube can be passed beyond the point of torsion and the bowel deflated sufficiently for complete detorsion to occur. This can be done by direct

vision through a proctoscope. Often patients with volvulus of the sigmoid correct their own difficulty by detorsion, by changing position, or by other conservative means. If operation becomes necessary as an emergency procedure, detorsion is first accomplished, and if gangrene is not present, resection of the bowel is postponed until a later date. The simple procedure of tacking the sigmoid colon to the anterior abdominal wall has been performed, but this does not appear to be of value in preventing recurrence of such a condition. In chronic volvulus of the sigmoid colon with recurrent attacks, resection of the involved colon is usually indicated. At operation the sigmoid is found to have a long mesentery with a very short span so that when the bowel loops upon itself, it becomes tightly twisted. Resection of this type of colon is simple, but because of the enormous disparity between the proximal and distal bowel the anastomosis may be a considerable problem.

For the technic of resection of the colon see chapter on operations on the colon.

**Meckel's diverticulum** with acute inflammation or ulceration due to ectopic gastric mucous membrane is always mentioned as a condition simulating acute appendicitis The finding of Meckel's diverticulum as a source of abdominal pain is unusual, but when it is encountered the diverticulum is resected and the bowel closed at the point of resection.

**Diverticulitis** of the colon is a common condition in persons beyond the age of forty and should be considered in all differential diagnoses of lower abdominal pain. It is said to occur in 5 per cent of the general population over the age of forty and may offer surgical problems when perforation, intestinal obstruction, abscess formation, or other complications arise. In many instances the presence of preexisting diverticulosis is known, and conservative treatment may be carried out; however, if the condition is found at emergency operation, it must be treated according to the local conditions. If perforation has occurred, closure of the perforation is usually not very satisfactory and resection of the involved segment may be indicated. Resection is also carried out for obstruction, for enteric or vesicocolic fistula, etc. In the presence of acute inflammation the obstructive type of resection with exteriorization of both ends of the colon is the procedure of choice since direct anastomosis in the presence of infection may predispose to breakdown of the suture line.

**Idiopathic rupture of the spleen** may be encountered due to malaria or obstructive splenomegaly or other cause In such a situation splenectomy is indicated just as in traumatic rupture of the spleen. The technic for splenectomy is described elsewhere.

**Regional enteritis** sometimes known as terminal ileitis, produces abdominal pain which on occasion requires surgical intervention. If the diagnosis is previously unsuspected but is substantiated at laparotomy, it is probably wiser to defer resection of the involved bowel until a regime of medical treatment has been attempted. In addition to the usual measures designed to put the bowel at rest, the value of deep x-ray therapy in the treatment of this condition must be borne in mind. When elective operation is performed because of bleeding or obstruction or refractoriness of the disease, a wide resection of the involved bowel, even including the proximal ascending colon, is imperative, since the disease is so apt to recur in cases inadequately resected.

## TECHNIC OF EXPLORATION

Certain suggestions regarding the technic of exploration for acute conditions of the abdomen may be of value, and a few of these will be discussed.

The primary consideration in an acute surgical condition of the abdomen is that the patient's general condition be sufficiently good that operation can be undertaken. Loss of blood must be corrected by adequate replacement with whole blood transfusions. Dehydration also demands replacement of fluid and electrolytes in proper amounts. Particular attention to blood chemistry levels is necessary to prepare the patient for operation. Determination of values of serum sodium, potassium, chloride, carbon dioxide combining power, nonprotein nitrogen, and total and fractional proteins should be made prior to inauguration of any restorative parenteral fluid program. When venoclysis is not feasible because of shock, obesity, or trauma, fluids (including plasma and blood) can be administered rapidly by hypodermoclysis when hyaluronidase is injected through the clysis needles. Surgical intervention should be carried out only when the patient's general condition is such that the operative risk is reduced to minimal levels.

If appendicitis is considered to be the most likely diagnosis, a McBurney incision is preferred, although in women where there is reasonable doubt as to the exactness of the diagnosis a vertical incision is generally more advisable. If a McBurney incision is made in a young woman and a pelvic condition is found, adequate exploration can often be performed by extending the incision inferiorly, by dividing the anterior rectus sheath, and by dividing the internal oblique muscle across the line of its fibers.

The subcostal type of incision is to be preferred for exploration of the liver or spleen and gives adequate exposure for the proximal or distal transverse colon. This type of incision is to be employed, however, only when injuries in the mid or lower abdomen can be satisfactorily ruled out.

For most explorations for trauma and for uncertain diagnosis the vertical incision is to be preferred whether it be a muscle-retracting or muscle-splitting type of incision. In general, a right paramedian abdominal incision will afford access to all parts of the peritoneal cavity and can be extended for more adequate exposure. It certainly has the advantage of ease of accomplishment and of closure. Closure of wounds with nonabsorbable material is to be preferred, although continuous catgut sutures may save time in gravely ill patients, and retention sutures may be indicated in certain individuals.

The choice of anesthetic agent depends to a large extent upon the condition of the patient and cannot be prescribed as a routine doctrine. In patients in severe shock the anesthesia should be very light and should be accompanied by a heavy concentration of oxygen. Spinal anesthesia gives excellent relaxation for appendectomy and for many lower abdominal operations It may be employed for upper abdominal operations, but inhalation or intravenous anesthesia supplemented with curare is to be preferred here.

During operation the continuous administration of dextrose intravenously is used routinely, and blood transfusions are given as indicated.

Since patients with acute surgical emergencies of the abdomen are gravely ill, it is particularly important that the operation be performed expediently and with a

minimum of trauma from handling the viscera. The employment of meticulous surgical technic must not be discarded for the simpler administration of drugs to combat infection or to restore the patient's blood pressure.

The detailed technic of operations performed during the course of laparotomy for acute conditions of the abdomen will be found in the appropriate chapters for the discussion of related disorders.

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# CHAPTER 48

# PERITONITIS

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Of the many complications that may accompany abdominal surgery, peritonitis is outstanding and frequently fatal. It is essential for one who is doing abdominal surgery not only to understand the operative procedures that may be indicated in peritonitis, but to comprehend the anatomy, physiology, and pathology of peritonitis. Peritonitis may be defined as a protective and a reparative response of the peritoneum to injury. There are some types of peritonitis, as pneumococcic and probably gonococcic, in which operation is of little if any benefit and is usually contraindicated. In the more common type of peritonitis following infection from, or operations upon, the gastrointestinal tract, early recognition of the disease and prompt treatment are essential for a satisfactory recovery.

It is important, then, to know not only when to operate for certain types of peritonitis but also when not to operate.

## ANATOMY AND HISTOLOGY

The peritoneum is the largest serous membrane in the body. Hertzler measured the peritoneal and the cutaneous surfaces of twenty cadavers and found that the average of the measurements for the former was 3,268 square inches and, for the latter, 3,436 square inches. Thus the opinion usually held that the surface area of the peritoneum is about equivalent to the cutaneous surface area of the body is approximately correct.

A part of the peritoneum is applied to the abdominal wall, the remainder being reflected over the viscera contained in the peritoneal cavity. In the male the peritoneum is a closed sac, but in the female the free ends of the fallopian tubes open directly into the peritoneal cavity The surface of the peritoneum is covered with flattened cells which are variously called epithelium, endothelium, or mesothelium.

The lining cells of the peritoneum have undulating margins, the corners being frequently pushed between the sides of adjoining cells. This irregularity may be accentuated by contraction or by successive contraction and expansion, particularly on the undersurface of the diaphragm. The cells of the peritoneum differ in form from the endothelium lining the blood and lymph vessels. The latter are usually arranged with the long axis of its cells parallel with the axis of the vessel, and the cells are elliptoid in shape and more irregular in size than the peritoneal

cells. The cells of the peritoneum are quite flat and have ovoid nuclei. In staining, they may group themselves in such a manner as to suggest stomas or stigmas. However, these openings, formerly supposed to afford an exit for the exudate of the peritoneum, have been proved to be artefacts in the staining and do not actually exist. The nucleus is usually situated about the center of the cell but may be eccentric; the long axis corresponds to the long axis of the cell. There may be two nuclei in a cell. The cytoplasm of the cell in the fresh stage is transparent.

Though some authorities have described cilia on the parietal peritoneum, Hertzler seems to have demonstrated that these so-called cilia were merely deposits of fibrin from the coagulation of fluid normally covering the cells. The cells are held together by an intercellular substance, which was thought by some to be lymph between the cells but has been more generally accepted as an intercellular cement which is different from the fluid in the lymph vessels. If the intercellular connection between the cells is broken and the substance beneath the cells is permitted to come in contact with the blood, coagulation occurs.

The pits in the peritoneum that lines the diaphragm are doubtless caused by folds in the peritoneum and may disappear when the peritoneum is carefully stretched. There seems to be no essential difference between the peritoneum which lines the diaphragm and that elsewhere in the abdominal cavity.

The discredited stigmas and stomas were formerly the basis of false theories as to absorption from the peritoneum. As they were supposed to be far more abundant on the undersurface of the diaphragm than elsewhere, it was assumed that absorption from the peritoneum of the diaphragm was particularly rapid. It is generally accepted now, however, that this is not true and that the capacity for absorption from the peritoneum, so far as its histologic structure is concerned, is about the same everywhere. One of the reasons given for the treatment of peritonitis by placing the patient in a sitting position was that by gravity the peritoneal exudate should be directed away from the diaphragm, where absorption through the stigmas and stomas was rapid. When fluid, such as salt solution, was given intraperitoneally for absorption, the patient was often placed in the Trendelenburg position, thus bringing the fluid more in contact with the undersurface of the diaphragm. The upright position has proved of value in the treatment of peritonitis chiefly because the exudate may be gathered into one small portion of the peritoneum, i.e., in the pelvis, where it can be more readily removed and will have a smaller area for absorption than if smeared over the whole peritoneal surface. Then, too, it is probable that even though the diaphragmatic peritoneum has no more capacity for absorption than the peritoneum elsewhere, the movements of respiration—the contraction and relaxation of the diaphragm with the liver beneath it—may act somewhat as a pump and mechanically force exudate into the peritoneum more rapidly than it would be absorbed without such alternate compression and relaxation.

Beneath the layer of lining cells is a basement membrane, made up of connective tissue fibrils arranged in parallel bundles and bound together with a cement substance. The cement substance appears not only to hold the connective tissue fibrils of the basement membrane together but to keep the cells in place much as tiles would be held by cement beneath them. In irritation of the peritoneum an

excessive amount of cement substance is apparently one of the first products of peritoneal exudation, as it is emitted between the cells and forms a fibrinous discharge.

Beneath this basement membrane is a layer of loose connective tissue, through which course blood and lymph vessels. In regions where the peritoneum is less mobile than others, as over the bands of the colon, the central tendon of the diaphragm, and over the liver and spleen, there is a small amount of connective tissue. The connective tissue in other regions, such as the parietal peritoneum, is more abundant and frequently contains much fat.

The blood vessels of the peritoneum may be divided into those that can be seen under normal conditions and those that are not visible. The latter are doubtless abundant not only in the peritoneum but in other tissues of the body and are called by Hertzler potential vessels. Ordinarily these small vessels do not contain red blood cells and are invisible. They probably transport serum, and possibly some white blood cells may make their way through them. In the presence of irritation they quickly dilate and become active with circulating blood. It is these vessels that under the sudden stimulus of irritation or inflammation provide the diffuse redness of the peritoneum. They can be demonstrated experimentally by the injection of a solution of silver nitrate and appear under the microscope to divide the peritoneum into quadrilateral areas. They arise at right angles from the visible vessels. They are separated from the endothelial cells only by their lining and a basement membrane.

The lymphatics of the peritoneum lie in the same stratum of connective tissue in which the blood vessels are found, only probably somewhat deeper. They form a network of relatively large vessels, irregular in size. The large lymph channels are connected by fine canals, but there seems to be no organic connection with the blood vessels or with the connective tissue spaces. The lymph channels are apparently a closed system, just as the blood vessels are, and interchange with the connective tissue spaces is doubtless a chemical process and does not involve an actual mechanical connection with the special spaces. Lymph vessels of the peritoneum are uniformly distributed, and the peritoneum of the diaphragm probably possesses no more abundant lymphatics than the peritoneum elsewhere. The lymphatics of the diaphragm doubtless communicate with the thoracic lymphatics, though the communication is by ordinary channels and not through any special perforations, as has been sometimes assumed. One would no more speak of communication of these lymphatics in this manner than one would speak of perforation of the arteries and veins in the intestinal wall. Lymphatic currents from the peritoneum over the diaphragm lead into the lymph nodes of the mediastinum and not to the pleural surface.

## PHYSIOLOGY

In addition to providing covering for the gastrointestinal tract and other intra-abdominal viscera, one of the major functions of the peritoneum is to act as an absorptive surface for fluids, toxins, and bacteria in the abdominal cavity. By virtue of its great extent the peritoneum offers a very active absorptive surface and is invaluable in the control of infections. The method of absorption of foreign

substances from the peritoneal cavity is not definitely known but undoubtedly is achieved both by the lymphatic system and through the blood vessels. As has been indicated above, most of the lymphatics from the peritoneal surface drain supradiaphragmatically into the mediastinal lymph nodes and thence into the right lymphatic channel before emptying into the vena cava. On the other hand, the lacteal lymphatics of the intestinal tract empty into the thoracic duct directly.

In order to understand more fully the mechanism of repair when peritonitis has developed, it is essential to trace the steps in the development of peritonitis and the factors which influence the treatment. When the peritoneum has been contaminated by soiling from the gastrointestinal tract or from other sources, a protective reaction is immediately set in force. The first step is that of fixation of the foreign material by an outpouring of lymph and fibrin, and an attempt is made to localize the source of irritation. After fixation of the contaminants by the plastic type of exudate, phagocytic cells migrate in large numbers to the area and attempt to dispose of the bacteria and other foreign matter. Polymorphonuclear leukocytes and mononuclear phagocytic cells are engaged in this process. As is characteristic in all acute infections the predominant cell at first is the polymorphonuclear leukocyte, whereas the mononuclears appear later in the course of the disease. If the protective forces including the cellular elements and the local antibodies are successful in combating the infection, complete absorption of the foreign material takes place and the fibrin is absorbed or replaced by the ingrowth of fibrous tissue. Intraperitoneal adhesions are prone to follow peritonitis, although the degree with which fibrous bands are formed varies tremendously in different individuals.

If the protective forces which are called into play after contamination of the peritoneal cavity by bacteria are unable to combat the infection successfully, the invading bacteria proliferate rapidly and elaborate their toxic substances. Necrosis is not common in peritonitis, but the severity of such infections and the frequency of fatalities result from blood stream absorption of toxins from the peritoneum, whereas particulate matter is usually absorbed through the lymphatic vessels. Toxins are most often carried into the blood stream directly by the small vessels in the peritoneum and in the mesentery. Successful removal of bacteria and toxic substances from the peritoneal cavity depends to a large extent on the degree and extent of peritoneal inflammation, interference with respiratory and diaphragmatic movements, and posture. It has been noted that when diaphragmatic movements are hindered by increased intra-abdominal pressure the rate of absorption of bacteria and toxins is delayed and the spread of infection is stimulated. As a corollary to this it was felt that the employment of Fowler's position was of considerable value in delaying the spread of peritonitis. It was postulated that if pus were directed away from the diaphragm, allowing for free movement of this organ, the bacteria and toxins would be better absorbed. On the other hand, absorption of these substances appears to be less rapid in the pelvic peritoneum, and pooling of the products of peritonitis in the pelvis often may result in abscess. One of the major purposes of the Fowler's position was to prevent the development of subdiaphragmatic abscess and the inclusion of the infecting substances in a relatively small area of the peritoneal cavity, that is, in the pelvis. It may be that absorption of toxic substances is less rapid in this region, but if an abscess forms here, it is subject to ready drainage. Undoubtedly the value of Fowler's position in the

treatment of peritonitis has been exaggerated, although in some cases a pelvic abscess has been substituted for a more dangerous upper abdominal abscess.

The efforts of the surgeon in treating peritonitis should be directed toward aiding this remarkable protective surface in the disposition of bacteria and toxins and in the prevention of abscess formation. It has been mentioned that diaphragmatic movement is conducive to better absorption of toxins and bacteria and that intra-abdominal tension by decreasing diaphragmatic movements tends to slow down the absorption of these substances One of the major factors in preventing the development of abdominal distention is the preservation of intestinal motility. Intestinal decompression by gastric syphonage and by the application of measures to increase peristalsis should be encouraged. It has been shown that stimulation of the gastrointestinal tract occurs after chewing or swallowing. For this reason, sipping of water and early ingestion of food are urged if gastrointestinal motility can be preserved. Various drugs can be employed to stimulate the motility of the gut. Considerable controversy exists regarding the use of morphine; however, at the present time it would appear that in peritonitis motor activity of the digestive tract is stimulated by the repeated administration of small doses of morphine every three or four hours. Another beneficial effect of morphine is that pain is reduced and normal physiology thus encouraged. The use of pituitrin and neostigmine is of some value in promoting intestinal motility. Finney has proposed the use of castor oil in cases of peritonitis to forestall the great distention in paralytic ileus, and this may be combined with the administration of high concentration of oxygen as suggested by Fine to promote absorption of nitrogen from the gut.

One of the major factors in the development of abdominal distention and spreading peritonitis is pain. It has been conclusively shown that the peritoneum is supplied with sensory nerves from the spinal cord, and the nerve endings are readily stimulated by intraperitoneal infection and by intra-abdominal distention The harmful effects of pain are obvious, and for this reason all attempts should be made to relieve the pain. A concomitant of pain is tenderness on palpation of the abdomen. When pain and tenderness arise from stimulation of the peritoneum, localization may be of great value in the differential diagnosis of the cause of the peritonitis.

Vomiting and fever are later developments in peritonitis and result from reflex stimulation and from overdistention of the stomach due to paralysis of the gut Fever results from the absorption of toxins and from the disturbance of temperature-regulating mechanisms in peritonitis.

## PATHOLOGY

Pathologic changes in peritonitis follow an orderly sequence. As indicated above, an immediate response to soiling of the peritoneal cavity is the production of a plastic type of exudate with the twofold purpose of fixing the offending materials in a local spot and of providing the cellular mechanism for absorption of these substances If the soiling is minimal and the reaction is adequate, complete absorption of the offending materials occurs and there is gradual dissolution of the exudate and a return to the normal state However, when the soiling has been extensive and the reaction very purulent, the resistance of the peritoneum may be overcome.

Generally speaking, the peritoneum is a remarkable structure, in that it is able to overcome gross insults of major proportion by its protective mechanism. On the other hand, repeated and prolonged soiling of the peritoneal cavity, such as from an unrepaired gunshot wound of the intestine, with continual leakage of feces, results in an overwhelming infection and frequently fatal peritonitis.

The microscopic appearance of the exudate in various stages of the peritonitis is of considerable diagnostic importance. Steinberg has graphically indicated the importance of adequate leukocytic response and absorption of the bacteria. In a "well-compensated" peritonitis the exudate contains large numbers of young polymorphonuclear leukocytes, many of which have absorbed bacteria. There is a minimum of bacteria free in the exudate. In very purulent infections, however, polymorphonuclear leukocytes are much decreased and bacteria are present in large numbers.

Abnormal visceral changes occur in the late stages of peritonitis, and these are usually due to the absorption of toxins from the peritoneal cavity. There is edema of the heart muscle and of the diaphragm. The lungs show passive congestion, and the spleen is enlarged and congested. Cloudy swelling occurs in the kidney, and edema may be present in the brain. It is to be emphasized that these changes occur only in overwhelming peritonitis, whereas in patients with good resistance peritonitis is usually overcome in the primary stages and does not involve other viscera

In his extensive studies of the peritoneum, Steinberg has found that the defense against infection of the peritoneum is dependent on four factors: (1) The presence of antibodies locally; (2) the integrity of the vascular system for transporting oxygen and antibodies and carrying away of waste products; (3) the availability of fixed tissue phagocytes, reticuloendothelial cells and the blood cells; (4) and finally, an active bone marrow for production of leukocytes which are so important in the inflammatory reaction. In addition to these factors influencing the defensive ability of the peritoneum, of equal importance are the severity and virulence of the invading organisms and the longevity of the soiling The average infection stimulates the bone marrow to activity and rapid liberation of young leukocytes which are so effective in combating bacteria, but absorption of toxins from a severe infection tends to suppress the bone marrow and reduce the individual's chances of recovery.

## CLINICAL PICTURE

The appearance of patients with peritonitis depends upon the severity of the infection and the adequacy of the individual response. Generally speaking, patients with peritonitis are prone to appear acutely and seriously ill, and all complain of pain and tenderness as a result of irritation of the nerve endings in the peritoneum There may be dehydration due to vomiting and as a result of outpouring of fluid into the peritoneal cavity. Abdominal distention is present in varying degrees. Vomiting is frequent. The patient appears listless and usually runs a septic type of fever. Leukocytosis is the rule, and its absence is usually a very bad prognostic sign. Splinting of the abdominal muscles is common, and there is a reluctance to change from the position of rest which is commonly assumed. In the late stages when dehydration has become marked and the patient is desperately ill, he may

assume the so-called "hippocratic facies." Shock is present in some patients, and when the infection has become generalized there may be mental aberrations late in the disease.

As has been indicated, the etiology of peritonitis is variable and may result from many sources of contamination of the peritoneal cavity. Primary peritonitis is unusual and is the result of a blood-borne infection with pneumococcus or hemolytic streptococcus.

## LOCALIZED PERITONITIS

Localized infection of the peritoneum may occur following appendicitis with perforation, salpingitis, diverticulitis of the colon, and well walled-off perforations of the gut. If adequate treatment is instituted to control the cause of local contamination, the reparative processes ordinarily are sufficient to effect complete and rapid healing. The severity of such infections depends upon the source, and, when due to a perforation of the intestine, they are usually of serious nature. Infection by the various intestinal flora produces severe peritonitis and must be vigorously treated, while peritonitis secondary to salpingitis of gonococcal origin gives acute and serious symptoms but is not of as grave a nature. The omentum is of considerable importance in localizing infections within the peritoneal cavity, and it is justly called the "policeman of the abdomen."

## GENERALIZED PERITONITIS

Generalized peritonitis results from overwhelming infection of the peritoneum due to continued soiling from an intestinal wound or from a lack of protective response of the individual Generalized peritonitis is usually an autopsy finding, and it is more commonly spoken of as a spreading infection when it is discovered at operation. This type of infection is apt to follow ruptured appendicitis, ruptured gall bladders, multiple perforations of the intestine due to trauma, and rupture of inflammatory lesions of the bowel such as diverticulitis and typhoid fever. Fixation of the omentum by previous operative scars or failure of the immune response contribute greatly to the development of spreading peritonitis.

Spreading peritonitis may, in fact, be mechanical and chemical in cases of perforated peptic ulcer, acute pancreatitis, or ruptured ovarian cysts. An individual suffering from this type of peritonitis is usually not as ill as are those suffering from diffuse infection with intestinal organisms.

When localized infection of the peritoneal cavity develops, and in the early stages a protective wall of exudate accompanied by the migration of omentum is found, the infection may develop to abscess formation. This is often seen in the case of a ruptured appendix which is well walled off and in tubo-ovarian abscess. It may also occur following perforation of the intestine from foreign body such as a toothpick or a fishbone, and subdiaphragmatic abscess may follow a number of intraperitoneal infections arising from such sources as ruptured appendicitis, perforated ulcer, and ruptured abscess of the liver. Pelvic abscess is frequently found in cases of peritonitis treated with Fowler's position and indeed this type of abscess may develop because of the position, whereas normally the response of the peri-

toneum might have forestalled the development of abscess. The problem of treatment of intraperitoneal abscess is different from that of localized or spreading peritonitis and will be discussed further.

## TREATMENT

The treatment of peritonitis depends upon the etiology. It is of primary importance to stop the source of contamination whether it be a ruptured appendix, an acute salpingitis, or a gunshot wound of the abdomen. As a general rule, all patients with peritonitis are treated with intestinal decompression by means of Wangensteen suction. Morphine is administered in small amounts at regular intervals, first, to decrease the accompanying pain, and, second, in an effort to promote resumption of intestinal motility. The stomach is kept empty, and only small amounts of fluids are given by mouth. Appropriate antibiotics are administered in large doses, and in overwhelming infections a combination of the antibiotics is usually employed. Parenteral infusions of fluids and electrolytes are employed as needed, and whole blood transfusions are given as indicated. Most cases of peritonitis are surgical in nature, although not all require operation. If operation is to be employed, certain general principles are essential. First of all, shock and blood loss must be vigorously combated prior to the institution of the operation. At operation a high concentration of oxygen is employed during the anesthesia A liberal incision is used in order to give adequate exposure and to facilitate the operation. The surgeon must be prepared to handle any cause for peritonitis which may be encountered, and the proper type of operation can only be selected at laparotomy.

Postoperatively the maintenance of intestinal decompression, the replacement of fluids and electrolytes, the employment of rest, and the continued use of antibiotics are combined and the Fowler's position used if localization of an abscess in the pelvis is desired. Early ambulation is encouraged.

It is beyond the scope of this chapter to describe the detailed treatment of peritonitis from many different sources, but the chapters on the acute abdomen, appendicitis, and other subjects may be consulted Certain specific types of peritonitis of a special nature will be briefly discussed further.

## SPECIAL TYPES OF PERITONITIS

In addition to the usual types of peritonitis encountered from infections and perforations of the gastrointestinal tract, there are certain specific and unusual types of peritonitis.

Bile peritonitis results from rupture of the biliary tract or liver and is of particular importance. A very fulminating type of peritonitis occurs following leakage of large amounts of bile into the peritoneal cavity. Characteristically, there is a substantial amount of shock accompanied by a large outpouring of fluid into the peritoneal cavity with resulting dehydration and some cyanosis. Jaundice may develop late in the disease. Bile peritonitis may follow operations on the biliary tract where there is damage to the common bile duct or inadequate closure of openings in the biliary tree. It also may follow traumatic rupture of the liver or gall bladder and its ducts. The fulminating nature of this type of peritonitis demands early surgical intervention and closure of the source of bile leakage.

**Tuberculous peritonitis** is much less common now than formerly but is still seen occasionally, particularly in the Negro. It is usually secondary to tuberculous infection elsewhere in the body, although it may be primary in the peritoneal cavity. The infection is not so acute and is accompanied by symptoms and signs of chronic infection, intestinal disturbances, and gradual deterioration. Characteristically there is a doughy feeling to the abdomen. Tuberculous peritonitis is best treated medically unless surgical complications develop. These include intestinal obstruction, perforation, tuberculous enteritis, tuberculous fecal fistula, and tuberculous abscess. With the advent of streptomycin, the nonsurgical treatment of tuberculous peritonitis has been greatly augmented, and it is still the procedure of choice. It has been said that in protracted chronic cases of tuberculous peritonitis exploratory laparotomy and exposure of the peritoneal surfaces to sunlight or ultraviolet light may be of benefit. Other indications for operation include fecal fistulas, obstructing and perforating lesions of the gut, and tuberculous abscesses. Tuberculous peritonitis is usually accompanied by the production of many adhesions and also by caseation in the mesenteric lymph nodes. The mortality rate is variable and depends to a large extent upon the resistance of the host.

**Primary bacterial peritonitis** is rare but does occur following blood stream infection with pneumococcus and hemolytic streptococcus. The treatment of these types of peritonitis is purely medical and combines the use of sulfonamides and antibiotics with other measures.

**Gonococcic peritonitis** secondary to salpingitis sometimes becomes spreading in nature and involves the other regions of the peritoneal cavity as well as the pelvis The so-called Fitzhugh-Curtis syndrome of perihepatitis in association with pelvic peritonitis is well known and is followed by the development of violin string adhesions in these areas The sharp pains in the right upper quadrant in this condition are sometimes mistaken for pleuritic pains.

**Chemical peritonitis** may follow rupture of a sterile ovarian cyst or some other hollow viscus which does not contain pathogenic organisms. There usually is a large amount of fibrin, and a plastic type of exudate covers the peritoneal surfaces. Rupture of a pseudomucinous cyst of the ovary leads to the production of pseudomyxoma peritonei, and this condition may also follow rupture of a mucocele of the appendix. Peritoneal implantation of tumor tissue from serous cystadenomas of the ovary and from ovarian carcinomas may produce a condition similar to peritonitis with large amounts of intraperitoneal fluid

## MORTALITY AND PROGNOSIS

Peritonitis of any sort is a serious condition and must be treated with great judgment. It is of primary importance to close surgically any source of contamination which is producing the infection. Perforated peptic ulcers, ruptured appendicitis, and traumatic perforations of the gut must be handled surgically. In combination with the operations, the use of modern antibiotics has opened new vistas in the treatment of peritonitis and has encouragingly reduced the mortality rate from this disease. It is unfortunate that every laparotomy is accompanied by the threat of peritonitis even though the operation may be a so-called clean one. The employment of strict aseptic technic is urged, and the maintenance of good technic in bowel

surgery is of particular importance. The use of sulfonamide drugs and antibiotics in preparing the bowel for elective surgery has been a great factor in reducing the mortality rate in intestinal resection.

## INTRAPERITONEAL ABSCESSES

In treating any type of peritonitis one will encounter from time to time various types of intraperitoneal abscesses which result from unresolved infection. In general these may be grouped into three types—pelvic abscesses, intra-abdominal abscesses, and subdiaphragmatic abscesses. Each of these abscesses has characteristics which are determined by the anatomical location, and the method of treatment of each is specialized, depending upon the type. It is generally agreed that intraperitoneal abscesses are the result of very virulent bacteria causing localized infection which cannot be overcome by the local forces of resistance. For instance, a pelvic abscess or a localized iliac fossa abscess commonly follows ruptured appendicitis which has persisted for a number of hours with continuous contamination of the peritoneal cavity. Similarly, subdiaphragmatic abscess may be a sequela of inadequately treated perforated peptic ulcer. It is undoubtedly true that the incidence of intra-abdominal abscesses has decreased greatly since the introduction of sulfonamides and the antibiotic drugs; however, the principle of treatment in any type of abdominal abscess is the same as that of abscesses in other regions of the body. One cannot expect chemotherapeutic measures to combat localized collections of pus, and they must be drained surgically in the majority of instances

## PELVIC ABSCESSES

Abscesses localizing in the depths of the pelvis are commonly seen following various types of peritonitis, particularly that from acute appendicitis, tubo-ovarian infection, and perforated intestines. These are probably the most common intraperitoneal abscesses, and undoubtedly gravity plays a considerable part in their development, by the mere gravitation of intestinal contents or pus downward into the pelvic cavity. The role of the Fowler position in the development of pelvic abscesses has been pointed out above. The diagnosis of pelvic abscess is usually made by persistence of an elevated septic type of temperature curve, leukocytosis, continued pain, and sometimes pressure symptoms on the rectum or bladder. On examination one can find localized tenderness and fluctuation on digital examination of the pelvic viscera or rectum. Sometimes, when the abscess is large enough, it presents suprapubically. In the great majority of instances these abscesses must be drained surgically because of the complete walling off of the collection of pus in the pelvic cavity, but in some instances the combination of large doses of antibiotics with pelvic diathermy effects a cure. In those cases requiring surgical drainage the procedure of choice is proctotomy or colpotomy. Large tubo-ovarian abscesses and other adnexal abscesses in females can be drained by colpotomy, and in the male pelvic abscesses are drained preferably through the rectum. In either case the abscess cavity is first aspirated with a large-gauge needle, then opened widely with a stab wound, and drained by the insertion of rubber drainage tubes. Neglected cases of pelvic abscesses sometimes rupture spontaneously into the upper vagina or rectum.

## INTRA-ABDOMINAL ABSCESSES

Some cases of generalized peritonitis result in the development of localized collections of pus in the lesser omental bursa, the iliac fossae, or in a space bounded by coils of intestines. These abscesses are more resistant to treatment and are more difficult to drain than pelvic abcesses. The diagnosis usually is made by palpation of a tender fullness in the abdomen, and drainage is usually accomplished by laparotomy Such abscesses may follow diverticulitis, leakage from an intestinal anastomosis, and traumatic or inflammatory perforation of a hollow viscus.

## SUBDIAPHRAGMATIC ABSCESSES

The most difficult type of intraperitoneal abscess to treat is subdiaphragmatic abscess. This is more difficult to localize and to detect and, in established cases, causes a more serious illness. Subdiaphragmatic abscesses are usually divided into two major types—suprahepatic abscess and subhepatic abscess. Nearly all of these collections of purulent material are the result of a peritonitis, although occasionally they may be hematogenous in origin. In rare instances subphrenic abscess may follow suppurative disease of the thorax.

As in other types of intra-abdominal abscesses the diagnosis is usually made because of persistence of signs of infection coupled with local symptoms and signs. Very important is the finding of localized tenderness which is most marked over the twelfth rib and along the costal margins, accompanied by slight edema of the overlying soft tissues, limitation of respiration on the affected side, limitation of motion of the diaphragm, and, possibly, pleural effusion. The fluoroscope and roentgen ray are of great value in establishing the diagnosis. Subphrenic abscess is far more common on the right side than on the left, although left-sided subdiaphragmatic abscesses may follow perforated ulcers or a ruptured spleen. It is probably true that many minor subdiaphragmatic abscesses subside spontaneously and are not recognized, and some instances of persistent fever following operation with minor pulmonary symptoms may be the result of subphrenic infection.

The treatment of subdiaphragmatic abscess varies depending upon the location In the case of a right-sided subhepatic abscess the treatment of choice probably is drainage through an anterior approach. On the other hand, suprahepatic subphrenic collections may be drained very expediently through the posterolateral approach of Ochsner and Graves. This approach can be used for collections on either side with equal facility. It is to be preferred that the drainage of a subdiaphragmatic abscess be carried out extraperitoneally or extrapleurally so as not to produce a generalized infection. In this connection the technic of drainage by the method of Ochsner and Graves should be elaborated somewhat.

Under suitable anesthesia, the patient is placed on the side opposite the affected side, with a sandbag under the lower ribs The twelfth rib on the affected side is resected subperiosteally throughout its entire extent. A transverse incision is then made in the rib bed at the level of the first lumbar spine, care being taken not to enter the pleura The diaphragmatic attachment is separated, and the dissection is carried upward, depressing the kidney downward with the index finger. Palpation will reveal the presence of localized collections in the subhepatic or suprahepatic areas When the palpating finger reaches the point of fluctuation, the peritoneum is opened and the abscess drained adequately through the incision.

Through this incision adequate evacuation of abscesses located above the liver on the right side can be accomplished if the dissection is carried along the undersurface of the diaphragm until the abscess is encountered. On the left side the abscess may not be quite as well localized but can be similarly drained. Subhepatic abscesses situated laterally may also be located by palpation and drained through this route. Anterior subdiaphragmatic abscesses and particularly subhepatic abscesses are not approached as easily by this means and should be drained through an anterior incision. Drains are left in situ as long as there is drainage of pus, and this may be facilitated by frequent irrigations with Azochloramid or a similar solution.

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# CHAPTER 49

# GASTROPTOSIS; RESECTION OF VAGUS NERVES; CONGENITAL PYLORIC STENOSIS

GUY W. HORSLEY

## GASTROPTOSIS

Downward displacement or ptosis of the stomach usually occurs in connection with ptosis of other abdominal organs, particularly the colon A stomach that is markedly prolapsed, however, may still have good function, and no operation to restore the stomach to what would be considered its normal position should be done unless it seems indicated after a thorough study of the patient, as well as of the stomach itself, has been made. Gastric analysis will determine the composition of the gastric juice, and roentgenologic examination both with plates and fluoroscope will detect any motor irregularities. Occasionally, a prolapsed stomach becomes adherent to structures in the lower abdomen or in the pelvis. In sharp ptosis a kink may develop about the duodenum and produce a water-trap effect. If symptoms are severe and there is x-ray evidence of gastric retention which is due to the ptosis, gastric resection may be indicated.

Ptosis of the stomach practically never occurs without ptosis of at least the transverse colon and often of the whole colon. An operation to relieve ptosis of the stomach should be supplemented by efforts to support the transverse colon. In Coffey's hammock operation for gastroptosis, for instance, the gastrocolic omentum is fastened to the parietal peritoneum with sutures placed in a transverse line as far above the navel as is conveniently possible. It is obvious that this supports the colon as much as it does the stomach. The chief objection to this procedure is the postoperative pain due to the tugging on the parietal peritoneum, but it is definitely superior to procedures such as that of Rovsing, who carries sutures through the abdominal wall and through the anterior wall of the stomach and fixes the anterior wall of the stomach quite firmly to the anterior abdominal wall. In this operation there must be marked interference with peristalsis, which probably does not occur in the operation of Coffey with the mobile attachment of the stomach through the gastrocolic omentum.

An ingenious procedure has been adopted by Lambret. A long band of fascia is taken from the outer margin of the sheath of the left rectus muscle, leaving its upper end attached, and is carried through the abdominal wall and sutured along the greater curvature of the stomach somewhat after the Witzel method of burying a tube. On the pyloric side the end of the band is fastened to the round ligament of the liver This apparently gives good support and avoids pain which is the chief

Fig. 559.

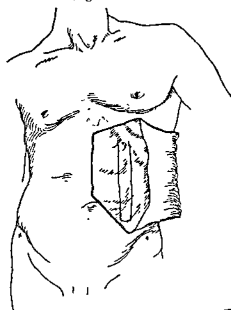
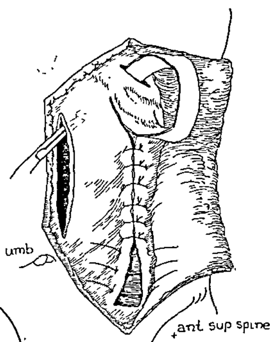


Fig. 560.



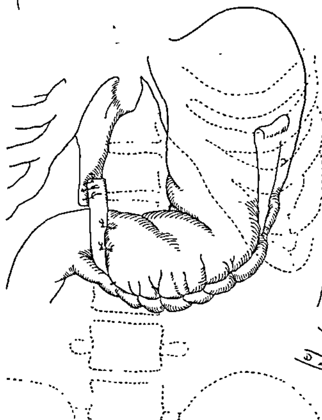



Fig. 561.

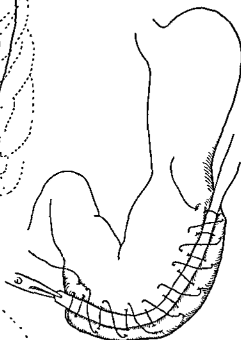


Fig 562.

Fig 559 —The abdominal incision for the operation of Lambret is shown. The flap from the anterior sheath of the rectus muscle is outlined

Fig 560.—The band of fascia from the anterior sheath of the rectus has been separated except at its base and is brought through a stab wound into the peritoneal cavity. The defect in the anterior sheath of the rectus muscle has been sutured

Fig. 561.—The band of fascia has been sutured along the greater curvature of the stomach, being buried somewhat after the Witzel method for gastrostomy.

Fig. 562.—The end of the band is sutured to the round ligament of the liver.

objection to the Coffey procedure (Figs. 559, 560, 561, and 562). However, the support of the lesser curvature, which physiologically is more important than the greater curvature, is neglected.

The operation of Beyea seems to fill this need of supporting the lesser curvature. According to his method, a reef is taken in the gastrohepatic omentum by several rows of sutures. A rather serious objection to this technic is that the central part of the gastrohepatic omentum is the weakest, and yet it is usually opposite the most pronounced portion of the gastric ptosis. Sutures in the central weakest part of the structure have the greatest strain to bear. Placing rows of sutures high up under the liver is sometimes a difficult procedure.



Fig. 563 —The suture begins on the left, taking a bite in the gastrohepatic omentum just above the stomach. A second bite is taken directly above this, and then the suture is carried to the right side and emerges just above the lesser curvature of the stomach near the pylorus.

The Beyea method has been modified by using a single purse-string suture of silk, in a small curved needle. The first bite of the suture is on the left side of the midline at the apparent beginning of the ptosis A firm bite is taken here in the gastrohepatic omentum just as it joins the stomach. The vessels are avoided. The second bite of the needle is in the gastrohepatic omentum at a point vertically above the first bite, well up under the liver and in the thicker tissue to the left of the midline Usually this operation is done in patients who are very thin, and it may be necessary for a firm grasp to include in this bite some blood vessels, particularly as the connective tissue seems to be stronger around these vessels. It is important not to puncture the vessels with the needle. The suture is then carried across to the

right side and takes a bite in the gastrohepatic omentum high up under the liver. The fourth bite of the suture is in the gastrohepatic omentum near the pylorus, vertically below the third bite and on the right side of the midline. It should catch the gastrohepatic omentum just as it enters the stomach in the pyloric region. (Fig. 563.) The needle may then take still another bite in the gastrohepatic omentum between the first and the fourth bites. The stomach is pushed up while this suture is gently tied. The suture should be of silk and is drawn snugly but without too much force. This elevates the stomach by its own natural ligament. The presence of nonabsorbable sutures in the gastrohepatic omentum causes some reaction and, besides the immediate mechanical effect, doubtless serves in this way to strengthen the otherwise thin gastrohepatic omentum. As an additional advantage, the stronger portions of the gastrohepatic omentum are approximated, and support for the stomach does not depend upon taking a reef in the weakest central part of this omentum.

In these cases there is almost always some prolapse of the transverse colon. If bringing up the stomach also elevates the colon sufficiently, there is no need for any further procedure, but usually the gastrocolic omentum is long, and lack of normal fusion of the omentum over the transverse colon may cause the transverse colon to fall still farther into the pelvis. The colon is brought into what would be its normal position and fastened by a series of silk sutures which take a reef in the gastrocolic omentum. The first suture is placed as far as possible on the left side and goes from the omentum just as it leaves the stomach to the omentum just as it reaches the colon. The sutures are continued at intervals well over to the right side. In this manner the colon is brought up close to the greater curvature of the stomach.

It is important to place the patient in bed with the foot of the bed slightly elevated. Feeding through the stomach should not be begun for at least three days after the operation, and then in small amounts. The patient is supplied for two or three days with sufficient nourishment and water and salts by the intravenous administration of dextrose in Ringer's solution.

When definite symptoms are occasioned by prolapse of the stomach and the colon, determined by a clinical and roentgenologic study, operations for relief of the prolapse are very beneficial. The peritoneum, as has been shown by Coffey, is one of the most satisfactory means of holding up displaced abdominal viscera. If too great strain is not placed upon the stomach until the sutured peritoneal surfaces have had an opportunity to repair, the viscera will in all probability remain in their replaced positions. The operation just described gives the stomach and colon the advantage of normal anatomical support and their functions should be much less interfered with than by methods that introduce abnormal ligaments or fix the stomach to the abdominal wall in such a manner as of necessity must interfere with peristalsis.

When the gastroptosis is accompanied by marked relaxation of the abdominal wall, the support from the abdomen should be rendered more effective. The upper incision is closed by merely approximating the margins of the severed tissues of the abdominal wall, but an incision below the umbilicus somewhat to the right of the midline is made and is closed with sutures that overlap the inner layers of the abdominal wall as far as possible and take up much of its slack. The sheath of the rectus muscle on each side is opened so that the recti muscles can be closely approximated and their anterior sheaths are overlapped. The fat is dissected from the front of the

anterior sheath of the rectus muscle on each side, the left edge is folded under t right edge for about 7.5 cm, and fastened with a series of interrupted mattr sutures of chromic catgut somewhat similarly to the manner in which an umbili hernia is repaired. These sutures are all inserted before any one is tied, then tl are drawn taut, held by an assistant, and tied one at a time. The sheath of the ri rectus is sutured onto the surface of the left sheath, making a double-breasted eff In addition to this, Coffey recommended that the slack in the abdominal wall further taken up by a long incision in each iliac fossa, following the principles McBurney incision. The tissues are overlapped and sutured.

## RESECTION OF THE VAGUS NERVES

Walter Hughson has demonstrated experimentally that marked irritatio any point in the peritoneum tends to cause delayed emptying of the stomach dog He considers that this is due to a pylorospasm from stimulation throu reflex nervous arc of which the vagus constitutes the last link. Impulses thr the reflex produced a spasm of the pyloric sphincter and delayed the emptyi the stomach even though gastric peristalsis was actually stimulated. Hug divided the vagus nerves just as they enter the stomach, before the sympat fibers from the celiac axis have been distributed with them, and also farther in the stomach after they have combined with sympathetic fibers. He found the trauma in the cecum which had caused marked delay in emptying the sto had no effect when the gastric vagus nerves were severed either just enterin stomach or farther down where the branches of the vagus combine with the sy thetic branches.

Within recent years Dragstedt has extended the work of Hughson, and, ir of dividing only the left gastric vagus nerve, he does a more extensive and co operation by removing a section of both vagus nerves on the lower part esophagus. This operation may be done by either a transthoracic approach abdominal approach. Since it is best to do bilateral vagotomies along with other type of gastric procedure, it seems best to use the abdominal approac to do the two procedures together. The transthoracic approach is the easier two, but unless some operative procedure for facilitating the emptying stomach has been done recently, the abdominal operation is the one of choi

If a Levine tube is placed through the esophagus into the stomach befor ing the operation for vagotomy, whether it is a transthoracic or transabd approach, the operation is made easier and the esophagus is more readily ide A left paramedian or midline incision is made from the xiphoid cartilage d or slightly beyond, the umbilicus. An adequate incision with good relaxati much to facilitate the operative procedure. After the abdominal cavity is the left lobe of the liver is pulled downward and slightly to the right to exp coronary ligament of the liver. This ligament is avascular and is divided left lobe of the liver is then retracted to the right and the lower end of the gus and the cardiac end of the stomach are exposed. The peritoneum o esophagus is grasped with forceps as it leaves the edge of the diaphragm cised With gentle blunt dissection, using the scissors and finger, the hiatus in the diaphragm about the esophagus is enlarged, and the esophagus is fre some of the surrounding tissue. The finger is placed around the esophagus

esophagus is pulled down into the abdominal cavity for several centimeters. The esophagus can be held down by a small rubber tissue drain or an umbilical tape placed around the esophagus and used for traction. The vagus nerves can now be readily palpated, the left nerve being anterior and the right nerve posterior. The nerves are dissected out for several centimeters, then clamped and divided as high as practical. A small section is removed from each nerve, and both ends are ligated with a silk suture. A careful inspection is made of the esophagus to be certain that all fibers of the nerves have been cut, as in a large percentage of cases there are small fibers in addition to the two large trunks. In other cases there is a plexus of small nerves rather than distinct trunks, in which case a meticulous search for the smaller nerve fibers is essential for a satisfactory result. The peritoneum about the esophageal hiatus is closed with catgut and the lobe of the liver is allowed to return to its normal position. The remaining part of the operation, whether it be gastroenterostomy, pyloroplasty, or partial gastric resection, is now carried out.

## CONGENITAL PYLORIC STENOSIS

The operative treatment of congenital pyloric stenosis has gone through various phases, beginning with gastroenterostomy, which was first performed for congenital pyloric stenosis by Lobker in 1898 and for about fifteen years remained as the surgical treatment of this disease. Pyloroplasty was then introduced, but on account of the stiffness of the gastric muscles and the difficulty of suturing them it was never popular. Fredet in 1907 did a submucous pyloroplasty by an incision down to the submucosa and attempted to suture this wound transversely. Rammstedt in 1912 cited the advantages of this procedure but did not suture the wound. This technic, which was initiated by Fredet and modified by Rammstedt, has become standard for congenital pyloric stenosis and, if carefully carried out in properly selected cases, with correct preoperative and postoperative treatment, gives satisfactory results with a very low mortality rate.

The problem of selecting the cases to be operated upon is sometimes difficult. Much depends upon the condition of the patient. If a baby is losing weight rapidly, naturally the operative treatment will carry a higher mortality rate; but with the need of surgical relief so obvious, medical treatment would probably not avail. Infants whose condition is only partially relieved by medical treatment are those for whom the choice between medical or surgical treatment is difficult.

Ladd and his associates have reported an operative mortality of 0.9 per cent in a large series of cases operated upon for this condition, and 225 consecutive cases without a death.

The preparation of the patient for operation is important. These infants should not be operated upon as an emergency when they are dehydrated and almost moribund. A delay of one or possibly two days is advisable, during which time the dehydration can be to some extent corrected by repeated hypodermoclysis of 5 per cent dextrose in normal salt solution or Ringer's solution, or by transfusion of blood if it seems necessary. The intraperitoneal injection of 5 per cent dextrose that is beneficial in other affections of infants is not advisable here because it causes a peritoneal congestion and interferes to some extent with the performance of the operation.

Careful conservation of the baby's body heat is important both during and after operation. This is readily done by using a wide board which has been padded

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esophagus is pulled down into the abdominal cavity for several centimeters. The esophagus can be held down by a small rubber tissue drain or an umbilical tape placed around the esophagus and used for traction. The vagus nerves can now be readily palpated, the left nerve being anterior and the right nerve posterior. The nerves are dissected out for several centimeters, then clamped and divided as high as practical. A small section is removed from each nerve, and both ends are ligated with a silk suture. A careful inspection is made of the esophagus to be certain that all fibers of the nerves have been cut, as in a large percentage of cases there are small fibers in addition to the two large trunks. In other cases there is a plexus of small nerves rather than distinct trunks, in which case a meticulous search for the smaller nerve fibers is essential for a satisfactory result. The peritoneum about the esophageal hiatus is closed with catgut and the lobe of the liver is allowed to return to its normal position. The remaining part of the operation, whether it be gastroenterostomy, pyloroplasty, or partial gastric resection, is now carried out.

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Careful conservation of the baby's body heat is important both during and after operation. This is readily done by using a wide board which has been padded

anterior sheath of the rectus muscle on each side, the left edge is folded under the right edge for about 7 5 cm., and fastened with a series of interrupted mattress sutures of chromic catgut somewhat similarly to the manner in which an umbilical hernia is repaired. These sutures are all inserted before any one is tied, then they are drawn taut, held by an assistant, and tied one at a time. The sheath of the right rectus is sutured onto the surface of the left sheath, making a double-breasted effect In addition to this, Coffey recommended that the slack in the abdominal wall be further taken up by a long incision in each iliac fossa, following the principles of a McBurney incision The tissues are overlapped and sutured.

## RESECTION OF THE VAGUS NERVES

Walter Hughson has demonstrated experimentally that marked irritation at any point in the peritoneum tends to cause delayed emptying of the stomach in a dog. He considers that this is due to a pylorospasm from stimulation through a reflex nervous arc of which the vagus constitutes the last link. Impulses through the reflex produced a spasm of the pyloric sphincter and delayed the emptying of the stomach even though gastric peristalsis was actually stimulated. Hughson divided the vagus nerves just as they enter the stomach, before the sympathetic fibers from the celiac axis have been distributed with them, and also farther down in the stomach after they have combined with sympathetic fibers. He found that the trauma in the cecum which had caused marked delay in emptying the stomach had no effect when the gastric vagus nerves were severed either just entering the stomach or farther down where the branches of the vagus combine with the sympathetic branches.

Within recent years Dragstedt has extended the work of Hughson, and, instead of dividing only the left gastric vagus nerve, he does a more extensive and complete operation by removing a section of both vagus nerves on the lower part of the esophagus. This operation may be done by either a transthoracic approach or an abdominal approach. Since it is best to do bilateral vagotomies along with some other type of gastric procedure, it seems best to use the abdominal approach and to do the two procedures together. The transthoracic approach is the easier of the two, but unless some operative procedure for facilitating the emptying of the stomach has been done recently, the abdominal operation is the one of choice.

If a Levine tube is placed through the esophagus into the stomach before starting the operation for vagotomy, whether it is a transthoracic or transabdominal approach, the operation is made easier and the esophagus is more readily identified. A left paramedian or midline incision is made from the xiphoid cartilage down to, or slightly beyond, the umbilicus. An adequate incision with good relaxation does much to facilitate the operative procedure. After the abdominal cavity is opened, the left lobe of the liver is pulled downward and slightly to the right to expose the coronary ligament of the liver. This ligament is avascular and is divided. The left lobe of the liver is then retracted to the right and the lower end of the esophagus and the cardiac end of the stomach are exposed. The peritoneum over the esophagus is grasped with forceps as it leaves the edge of the diaphragm and incised With gentle blunt dissection, using the scissors and finger, the hiatus opening in the diaphragm about the esophagus is enlarged, and the esophagus is freed from some of the surrounding tissue. The finger is placed around the esophagus and the

esophagus is pulled down into the abdominal cavity for several centimeters. The esophagus can be held down by a small rubber tissue drain or an umbilical tape placed around the esophagus and used for traction. The vagus nerves can now be readily palpated, the left nerve being anterior and the right nerve posterior. The nerves are dissected out for several centimeters, then clamped and divided as high as practical. A small section is removed from each nerve, and both ends are ligated with a silk suture. A careful inspection is made of the esophagus to be certain that all fibers of the nerves have been cut, as in a large percentage of cases there are small fibers in addition to the two large trunks. In other cases there is a plexus of small nerves rather than distinct trunks, in which case a meticulous search for the smaller nerve fibers is essential for a satisfactory result. The peritoneum about the esophageal hiatus is closed with catgut and the lobe of the liver is allowed to return to its normal position. The remaining part of the operation, whether it be gastroenterostomy, pyloroplasty, or partial gastric resection, is now carried out.

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with cotton and sheet wadding, and wrapping the baby's legs and arms snugly to the board. Heat conservation is also maintained by the use of hot-water bottles under the drapes during the operation.

Before the operation is started, it is advisable to aspirate the stomach contents. This will insure a smoother anesthesia and there will be less possibility of aspirating gastric contents into the respiratory tract during and after the operation.

The anesthetic may be local, or ether by the open drop method. If a sugar rag pacifier is used and the tissues are well infiltrated with 0.5 per cent procaine solution in which there is a small amount of Adrenalin, 0 2 to 30 c.c., the operation can be done with but little pain, and frequently there is no crying. Several points are important if the operation is to be undertaken under local anesthesia. The incision is made about 3.25 to 5 cm. long in the upper right rectus muscle. It should preferably be made so the middle of the incision will be over the lower border of the liver and the lower end of the incision well above the level of the navel. One of the dangers of the operation when done under local anesthesia is that sudden straining of the baby will produce an eventration of the intestines, which may quickly occur and will greatly complicate the situation. The margin of the liver tends to prevent this. The wound, however, should be carefully watched by both the surgeon and the assistant and on any attempt at straining moist gauze is placed over the wound and held firmly. These patients tolerate general anesthesia very well, and as a rule it is best to use open drop ether, in which case there is little possibility of sudden evisceration. Ladd and his associates prefer a gridiron type of incision to the right rectus, as they believe this gives better exposure, with less chance of evisceration. This incision is about 5 cm. in length and is made parallel to and one fingerbreadth below the costal margin, starting at the lateral edge of the right rectus muscle and extending laterally. The external and internal oblique muscles are divided in the direction of their fibers, while the transversalis and peritoneum are divided transversely in one layer.

When the peritoneal cavity is opened, the omentum may float into the wound. It should be gently returned and held back with gauze pads wet with salt solution. In infants and young children the omentum is almost like a viscid fluid and is sometimes difficult to control

In some cases the pyloric mass, which is easily palpated with the finger when the abdomen is opened, can be delivered into the wound with the finger and a small malleable retractor. If there is any difficulty about this, however, the tissue along the lower border of the stomach is caught with small mosquito or intestinal Allis forceps and the pyloric portion of the stomach is drawn up. Then by catching further bites with the forceps, the pylorus is easily delivered into the wound.

After delivery of the hypertrophied pyloric canal, it is caught between the finger and thumb of the left hand The tumor is held firmly and an incision is made beginning near the duodenum and going through the peritoneum and the superficial portion of the constricting fibers well onto what appears to be the normal wall of the stomach. Usually this incision is practically bloodless when made at the junction of the middle and upper thirds of the growth Care must be taken not to open the duodenal mucosa, as the line of demarcation between the thick wall of the congenital pyloric stenosis and the duodenum is very narrow. After making this superficial incision the remaining constricting mass is broken through with the handle of the knife. It is quite friable, and the submucosa bulges into the wound.

When this occurs, the incision is broadened by inserting a pair of small hemostatic forceps and gradually opening them. (Fig. 564.) In this way the constricting tissue is cleared, and the submucosa should bulge well into the wound throughout all of the incision from the margin of the normal stomach to the duodenum. The separation of the tissues at the duodenal margin should be particularly careful because, if constricting fibers are left there, little relief will be obtained, whereas if the dissection is too vigorous at this point the duodenal mucosa may be torn.

The practice of catching the edges of the wound with gauze and forcibly separating them may result in injury to the mucosa. The submucosa of the pyloric canal can be further freed if it seems necessary by gentle insertion of the handle of the knife, but if it bulges well into the wound sufficient relief will have been obtained.

Usually the blood vessels are so small that bleeding is easily checked by firm pressure of moist warm gauze for a minute or two; but if not, any bleeding vessels are caught with mosquito forceps and tied with very fine catgut. This is rarely necessary. If the raw surfaces of the severed constricting fibers tend to ooze, they are whipped over with fine plain catgut; though this, too, is not often necessary.

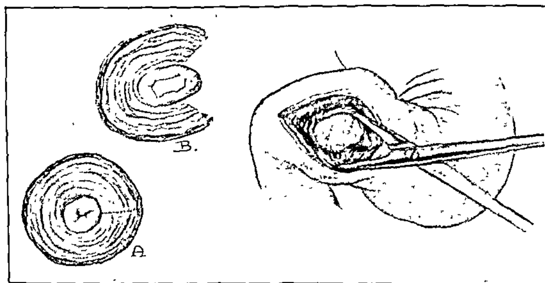



Fig 564.—An incision has been made and the submucosa of the pyloric canal is exposed. *A*, Cross section of congenital pyloric stenosis before the incision *B*, Cross section after the incision

If the duodenal mucosa is accidentally opened, the perforation is sutured with fine silk on a very fine curved needle. The ends of the silk are left long, are passed through portions of omentum, and are again tied, in this way further reinforcing the wounded mucosa. It is not necessary to bring omentum over the wound unless some complication such as perforation has occurred or there is persistent oozing of blood from the cut muscle edges.

After the bleeding has been controlled, the wound in the pyloric canal is again inspected to be certain that no constricting bands are left. The pylorus is dropped back, and the abdominal wound is sutured. Through-and-through retention sutures are placed at intervals of about 1 cm and are left untied until the peritoneum and the posterior sheath of the rectus muscle are sutured with fine chromic catgut. A few sutures of catgut are also placed in the anterior sheath of the rectus muscle. The skin is closed with fine silk, and the through-and-through sutures are tied

snugly, but not too tightly. Careful layer closure is carried out when the gridiron type of incision is used, but here retention sutures are not necessary.

The wound should be sealed from external infection by the urine, either by placing a pad of gauze over the wound and covering it with adhesive plaster, or by laying on the wound gauze soaked in compound tincture of benzoin. After the compound tincture of benzoin has dried, other dressing is applied.

The postoperative management of these cases is important. The body heat should be preserved by hot water bottles and by wrapping the baby in blankets. Hypodermoclysis of 5 per cent dextrose in Ringer's solution is given and, if possible, the baby is fed with breast milk. The use of hyaluronidase in the hypoclysis solution insures rapid and adequate absorption of fluids so that intravenous or other methods of administering parenteral fluids is not necessary. One or two hours after operation about 15 c.c. of water are given, followed an hour later by 4 c.c. of breast milk and 4 c.c. of barley water. The breast milk is repeated, giving eight feedings a day and alternating with water. These feedings are increased in quantity so that twenty-four hours after the operation the infant is taking 30 c c. at a time. Larger feedings are then given. If a supply of mother's milk is obtainable, it is much better than any milk made by formula, though it may be necessary to give modified milk.

The aftertreatment, so far as the diet is concerned, should preferably be in the hands of a competent pediatrician.

The Fredet-Rammstedt operation is so satisfactory that in our practice other more complicated methods have been abandoned.

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CHAPTER 50

# HOURGLASS CONTRACTION OF THE STOMACH; GASTROTOMY; GASTROSTOMY

GUY W. HORSLEY

## HOURGLASS CONTRACTION OF THE STOMACH

Often an hourglass contraction of the stomach, as shown in a roentgenologic examination, is due solely to spasm, though cicatricial stenosis following extensive ulceration or a midgastric resection occurs.

If the ulcer is still active, a partial gastrectomy is indicated. However, if the ulcer has healed and merely the cicatricial contraction is left, several operations have been suggested. A type of gastroplasty, using the principle of Heineke-Mikulicz in which an incision is made across the constriction and sutured in an opposite direction, has been done. The grave objection to this, however, is that all of the original scar tissue is left. It is probable that, later, contraction will again appear and the deformity will recur.

A rather wide resection of the adjoining portions of the two pouches of the stomach including the stenosis—the so-called sleeve or midgastric resection in which one stump of the stomach is sutured to the other—may in some conditions be permissible, though it is not a good operation. This procedure has the objection that a portion of the lesser curvature, which is the most important part of the stomach from a peristaltic point of view, is removed. However, if the stenosis involves the lesser curvature, doubtless the tissue which would function physiologically at this point has already been replaced by scar tissue. A sleeve, or midgastric resection, is also prone to result in another hourglass contraction.

On physiologic grounds it would seem much better to do a partial gastrectomy, preferably of the Billroth I type, in hourglass contraction from cicatricial stenosis than to attempt any method of plastic repair.

## GASTROTOMY

A gastrotomy may be indicated for the removal of foreign bodies, for exploration of the interior of the stomach, or for excision of benign tumors. Formerly ulcers of the posterior wall of the stomach were removed through a gastrotomy incision in the anterior wall Such a procedure, however, results in the suturing of the posterior wall from within the stomach, exposure is often unsatisfactory, a large amount of mucosa is embraced in the sutures and rendered necrotic, and a recurrence of the ulcer is quite probable. In view also of the well-known tendency of a certain percentage of gastric ulcers to become cancerous, it is preferable in a large ulcer adherent posteriorly to do a partial gastrectomy.

Benign tumors, while not common, are more frequent than has been generally accepted. The tendency of a benign tumor of the stomach to degeneration into cancer, particularly at its base, would make the indication for partial gastrectomy hold in some of these cases, unless the pedicle was distinctly limited and seemed to show by the absence of unusual thickening or ulceration that there was no suspicion of cancerous change. The pedicle of the tumor is tied and severed; or, if the growth is sessile and the mucosa over it apparently healthy, it would probably be better to remove the tumor through an external incision over the growth, shelling it out and leaving the mucosa intact, rather than to incise the mucosa over the tumor and remove it through the stomach. If, however, the mucosa has become thinned out or ulcerated, it would doubtless be preferable to excise this affected mucosa along with the tumor. Complete hemostasis in the tissues beneath the mucosa should be effected and the mucosa sutured rather lightly with fine suture material, either silk or catgut. In multiple papillomas partial gastrectomy is distinctly indicated, rather than making many small wounds in the gastric mucosa.

The ingestion of foreign bodies, such as glass or nails, is not uncommon in insane patients. In vaudeville formerly one of the popular acts was the swallowing of broken glass or nails. Usually this material passes through the gastrointestinal tract, but occasionally it is retained in the stomach. The accumulation of hair in the stomach as a hair ball has been described by many writers. Phytobezoar, particularly of persimmon seeds and grape skins, has been recorded, which requires surgical removal by gastrotomy.

In gastrotomy, a longitudinal incision in the abdomen is so placed as to give full access to the foreign body or tumor to be removed. If it is near the pylorus, the incision is made to the right of the midline, but if it is a large foreign body the incision should be to the left of the midline. The type of incision into the stomach depends upon the size and location of the foreign body or growth. A longitudinal incision in the middle of the anterior gastric wall involves but few large blood vessels and is closed readily. It is also more capable of being extended and gives a wider exposure It is better not to carry the incision over the region of the pyloric canal, because sutures in the mucosa in this region may produce a peptic ulcer. Soft-bladed clamps are usually not necessary. The stomach is caught with Allis forceps at the proposed ends of the incision. The incision at first is carried down only to the mucosa, catching the vessels before the mucosa is incised In this way unnecessary trauma to the mucosa is avoided. The Allis forceps are lifted up so that when the mucosa is incised the gastric contents will not spill. The surrounding tissues are packed off with moist gauze. A small opening is made in the mucosa and a suction tip is introduced and the liquid gastric contents are withdrawn. The incision is extended to permit extraction of the foreign body or excision of the tumor It is preferable to extend the incision to secure a good view and to extract the foreign body easily than to traumatize the stomach unduly by too strong retraction of the margins of the incision

In closing the gastrotomy wound the mucosa is united with a lightly applied continuous suture of fine chromic catgut The submucosa is approximated with fine chromic catgut, catching with the suture the small bleeding vessels in the submucosa In this way the mucosa will be inverted into the stomach as a flange and will act somewhat as a valve to protect the rest of the wound. If the larger vessels

in the muscular coats of the stomach have been secured, the smaller vessels in the submucosa can be readily caught with a fine needle and fine catgut, so making complete hemostasis without actually penetrating through the mucosa itself. A continuous suture of chromic catgut approximates the muscular and peritoneal layers without any attempt to invert the tissue. Finally the last line of interrupted sutures of fine chromic catgut is placed, burying the preceding sutures. If a transverse incision has been made, adjacent gastrocolic or gastrohepatic omentum is brought over the line of sutures.

The aftertreatment of gastrotomy follows the same general principles as of other operations upon the stomach. The stomach should not be permitted to become distended and should be given physiologic rest by a tube or catheter gastrostomy made at the time of the operation or by continuous gastric drainage with a Levine tube through the nose.

## GASTROSTOMY

Gastrostomy is one of the oldest of operations on the stomach, and was probably suggested by the well-known case of Alexis St. Martin that William Beaumont studied so carefully. Beaumont's work was the foundation of modern physiology of the stomach.

Egeberg first proposed the operation of gastrostomy in 1837. Sedillot of Strasbourg, after doing considerable experimentation on dogs, attempted the first gastrostomy in 1849, but the patient died. Sedillot then modified the technic by first suturing the stomach to the parietal peritoneum and later opening the stomach. In 1879 Petit gave a statistical report of 41 gastrostomies with seven successful results. In 1885, the year in which Billroth did his first type II gastrectomy, there were collected in the literature by Zesas 162 reports of gastrostomy.

The operation of gastrostomy may be divided into two classes. In one there is a rather large group of cases in which a fistulous tract is lined with the inverted peritoneum of the wall of the stomach or with granulation tissue. In these cases there is the hope of a valvelike action by inverting a portion of the gastric wall or by making an indirect channel. In the second type of gastrostomy, an epithelial lining for the fistulous channel is constructed.

The indications for gastrostomy are obstruction to swallowing, as caused by cancer of the esophagus, of the cardiac opening of the stomach, or by a stricture of the esophagus, or the need of postoperative drainage of the stomach in gastric surgery. Occasionally there are diseases of the pharynx or larynx that demand gastrostomy. If the condition that indicates gastrostomy is apparently temporary or is capable of being corrected, the type of gastrostomy in which the lining of the channel is the peritoneal covering of the stomach may be selected. When, however, the gastrostomy is to be permanent, as in extensive or undilatable stricture of the esophagus or in cancer of the esophagus, an epithelial lining, preferably the epithelium of the stomach, would better fill the indications.

The abdominal incision for approach to a gastrostomy has varied somewhat, and for a while it was the subject of much discussion. It was even stated that the stomach should be dilated with air in order to show its outlines. A favorite incision formerly used was in the left hypochondriac region parallel with and close to the costal arch. The purpose in placing such an incision was to approach the stomach

as near the cardiac end as possible so that the gastric opening would deliver the food directly into the cardiac portion of the stomach, simulating its normal ingestion through the esophagus.

The usual incision now made is through the left rectus muscle or through the midline. Often the operation is done in patients dehydrated and undernourished who would stand a general anesthetic poorly, and local anesthesia may be used. If the gastrostomy is not to be permanent, that is, if the condition demanding a gastrostomy can be corrected, a technic in which a prolonged channel is lined first with peritoneum and later with granulation tissue may be selected. For this, either the Stamm or the Witzel method is easy of execution and fairly satisfactory. Usually when this type of gastrostomy is indicated, the stomach is small, due to the difficulty of ingesting food A gastrostomy that would be satisfactory on a large stomach may not be advisable on a contracted stomach or vice versa.

If the stomach is not too greatly contracted, a Stamm operation can be done. The stomach is exposed, a pouch of it brought into the wound, and a purse-string suture is inserted. The stomach is punctured within the field enclosed by the purse-string suture. A medium-sized soft rubber catheter is introduced so that its eye is well within the cavity of the stomach, the purse-string suture is tied, the end of the suture is carried around the catheter, and it is again tied. A series of purse-string sutures is then applied, infolding the catheter and making an inverted cone of the surrounding wall of the stomach. (Fig. 565.) The end of the last purse-string suture is left long and passed through the parietal peritoneum. The stomach is also attached to the parietal peritoneum by sutures at other points, leaving the tube emerging from the abdominal incision, the rest of which is closed.

It may be more satisfactory to introduce the catheter through a stab wound in the abdomen after the stomach has been exposed. When it has been found at what point the stomach will, with least tension, make contact with the abdominal wall, a stab wound is made there, and the catheter is passed through and then placed in the gastrostomy wound as described; or the end of the catheter may be carried through the stab wound after it has been fixed in the gastrostomy. The objection to the latter procedure is that there is greater possibility of infection of the stab wound after the tube has been fastened in the stomach. This objection, however, can be overcome by clamping the catheter about its middle before it is inserted into the gastrostomy wound In whatever manner the tube is brought through the abdominal wall, the stomach just above and below it is fastened to the parietal peritoneum with a few sutures of catgut Ordinarily the contents of a stomach with normal gastric juice are almost sterile and moderately antiseptic, but, in patients with cancer of the esophagus or who are markedly undernourished, the gastric juice may not be normal and small fragments of food or infectious material carried from the neoplasm may render the gastric contents actually septic. It is safer to assume that the stomach contents are not sterile in these cases

In the Witzel method of gastrostomy the first [illegible] identical with the first
step in the Stamm gastrostomy. A catheter is ins [illegible] the stomach through
the grasp of a purse-string [illegible] hich is then [illegible] nd the catheter and
again tied. Here, as in [illegible] ies and ente [illegible] is thought best not
to pass a suture through tl [illegible] cause frequ [illegible] ill be le [illegible] out
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of the stomach, the cathete [illegible] e stomach [illegible] e of [illegible] ti-

meters and buried in a groove which is converted into a tunnel by sutures bringing the wall of the stomach over the catheter. (Fig. 566.) This operation is indicated when, on account of the small size of the stomach, it is difficult to raise a large cone from the gastric wall, as in the Stamm operation.

In the Marwedal gastrostomy an incision is made through the peritoneal and muscular coats of the stomach and the tube is buried obliquely on the submucosa so that it runs through the wall of the stomach in an oblique course, as in the Coffey transplantation of the ureters.

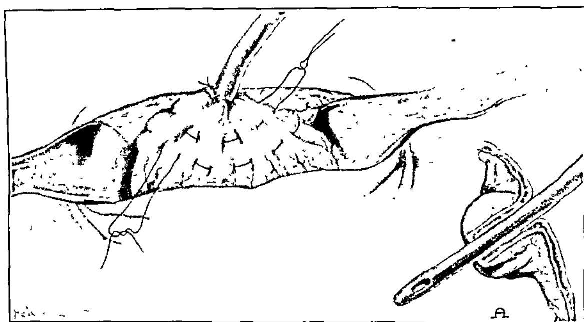



Fig. 565.—The Stamm gastrostomy. A tube has been inserted in the stomach and transfixed with a purse-string suture. Other purse-string sutures are applied. Insert *A* shows a sectional view of the Stamm gastrostomy when completed

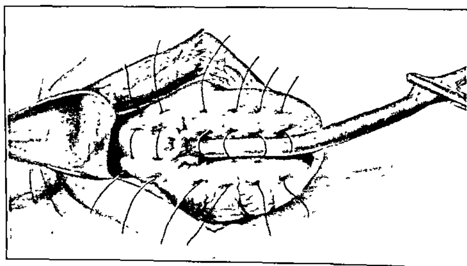


Fig. 566.—The Witzel gastrostomy. The tube has been fastened in the stomach and laid on the surface of the stomach. Sutures which will bury the tube have been placed

None of these gastrostomies should be employed unless there seems to be a reasonable chance of the lesion which demanded the gastrostomy being cured.

The objection to this type of gastrostomy is that the inverted tissue does not really act as a valve. The channel of the fistulous tract is soon lined with granula-

tions and may be a source of infection or, if it is not, tends to remain fairly rigid, so that there is leakage from the stomach unless the tube is kept constantly in place as a plug. Even then a slight leakage around the tube may permit the escape of gastric contents with an irritating effect not only upon the fistulous tract but upon the skin. These are sources of annoyance and potential infection.

A temporary gastrostomy after operations on the stomach is often indicated. After almost every operation on the stomach it is well to give the stomach physiologic rest. Dilatation of the stomach may come on unexpectedly and strains the tissues and the sutures. In order to accomplish this desirable object, it has been customary to place a Jutte or Levine tube through the nose into the stomach immediately after the operation. In some patients the presence of this tube is quite objectionable, and to reinsert it at stated intervals becomes a nuisance. If it stays in continuously for several days it causes an irritation in the nose and pharynx. A simple tube or catheter gastrostomy with every stomach operation, including pyloroplasty, gastroenterostomy, and partial gastrectomy is advised and has been used successfully and without complication for years.

For the past ten years a transgastric enterostomy for immediate postoperative tube feeding has been found to be helpful and is done with the gastrostomy. Before the anterior row of sutures in the anastomosis following a gastric resection is completed, a sharp-pointed hemostat is introduced into the stomach and thrust through the lower anterior wall of the stomach about 3 or 4 cm. from the gastric wound. It should be pushed through at right angles to the wall of the stomach, and not obliquely. After perforating the stomach from within outward, a soft rubber catheter, No. 14F, in which there are additional perforations near the tip, is caught with the hemostat and about 4 to 6 cm. of the catheter are drawn into the stomach. A second catheter is then brought through the same opening and the end is placed down into the duodenum or jejunum. A purse-string suture of catgut is placed around the catheters and tied snugly. A second purse-string suture is placed around these catheters and tied as the catheters are pulled inward through the stomach. This inverts the first suture row. The ends of this last suture are left long (Fig. 601). The catheters are clamped about their middle and left in position until the stomach operation is completed. Then a stab wound is made about 4 cm. to the left of the abdominal incision at a point where the gastrostomy wound in the stomach can be easily brought to the parietal peritoneum of the abdominal wall, and the ends of the catheters are brought through. By everting the left side of the abdominal wall the stab wound in the parietal peritoneum can be readily exposed. The long ends of the purse-string suture are passed through the parietal peritoneum of the abdominal wall. Two or three other sutures unite the stomach to the parietal peritoneum. A tag of omental fat is brought around the gastrostomy wound and fastened with fine catgut sutures. This fat not only makes the exit of the catheters from the stomach safer, but tends to prevent too firm adhesions to the abdominal wall The catheters are drawn up snugly and at their exit from the skin of the abdomen a strip of adhesive plaster is wrapped around the catheters and a suture is passed through the margin of the skin and the adhesive plaster.

This type of gastric drainage is far more comfortable to the patient than the introduction of a tube through the nose, and the drainage is more efficient. Feedings are started through the enterostomy tube on the second day while the stomach

is kept deflated until it begins to empty. The patient is allowed clear liquids immediately; this keeps the patient more comfortable and affords better oral hygiene.

By this operation the muscular coats of the stomach are not cut, but are merely pushed apart by the hemostat, much as in the gridiron or McBurney incision in the abdominal wall. When the catheters are withdrawn, the muscular coats readily close, and there is hardly ever any leakage of the gastric contents. This procedure can hardly be effected from without, because the sharp-pointed hemostat would tend to push the mucosa away from the muscular layer. However, a small stab wound in the stomach with the tip of a sharp-pointed knife might be made, and the wound dilated with a sharp-pointed hemostat. A few more of the muscle fibers would be injured than would occur if the hemostat is thrust from within outward, though probably not enough to be of any serious consequence.

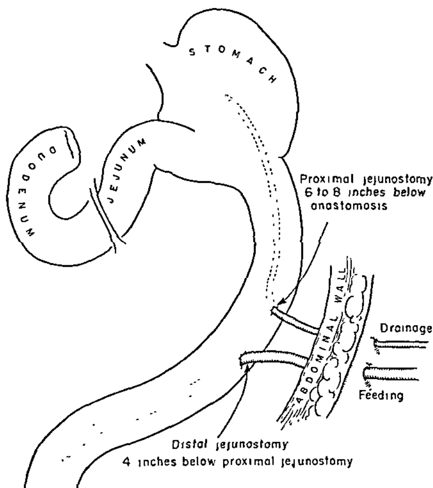



Fig 567 —Postoperative gastrostomy and enterostomy of Allen and Donaldson

In certain cases, because of the type of gastrectomy or the high position of the stomach in relation to the lower ribs, it is impossible to carry out this type of postoperative gastrostomy. Allen and Donaldson described a procedure which is better suited in these conditions. After the anastomosis has been completed, a purse-string suture of chromic catgut is placed in the jejunum at a point about 15 cm. below the anastomosis. A stab wound is made in the bowel in the center of the purse-string suture and a 14F catheter threaded on a stilet is passed into the bowel and up through the anastomosis well into the stomach. The suture is passed around the catheter and then tied. A second purse-string suture is placed around the catheter

and tied as the catheter is pressed inward. This infolds the bowel wall next to the catheter and lessens the possibility of leakage. A second tube for feeding is placed about 6 to 8 cm. below the first tube with the catheter and leading down the bowel lumen. These tubes are brought out of the abdominal wall through small stab wounds as has been described above (Fig. 567). This method of gastrostomy and tube feeding is applicable only after a Billroth II type gastrectomy.

A gastrostomy channel lined with epithelium accustomed to gastric juice is the ideal method if the gastrostomy is to be permanent.

Tavel has suggested the transplantation of a segment of the jejunum which is left attached to its mesentery and constitutes a tunnel between the stomach and the skin. This procedure is quite complicated, requiring extensive interference with the bowel and stomach. The segment of jejunum itself may be irritated by the gastric juice as shown by the occurrence of jejunal ulcers after gastroenterostomy.

The ideal gastrostomy would have a channel lined completely with the gastric mucosa. The method of Ssabanejew-Frank does this, but as the demands upon the stomach wall are even greater than in the Stamm gastrostomy, it is necessary to have a large mobile stomach in order to perform the operation. A point in the cardiac portion of the stomach, as far from the pylorus as possible, is drawn through an incision in the left rectus muscle. The parietal peritoneum is sutured to the base of this cone of the stomach about 7.5 cm. from its apex. The parietal peritoneum and posterior sheath of the rectus are closed around this projecting cone. Another incision is made 7.5 cm. to the left of the main incision, and the subcutaneous tissue between these two incisions is undermined. The apex of the cone of the stomach is drawn through this tunnel and fastened to the margins of the skin with sutures. The skin over the first incision is closed. It is advisable to postpone the opening of the apex of this cone of the stomach for at least several hours or possibly a day unless the emergency is great, in order to permit adhesions of the peritoneum to the surrounding tissue through which the gastric cone has been drawn.

This operation is supposed to prevent leakage, partly because of the indirect course of the gastric cone, and partly because the base of the cone is drawn through the rectus muscle, which acts somewhat as a sphincter.

The method of utilizing the skin of the abdomen to form an epithelialized tube would be unsatisfactory because of the irritating effect of the gastric juice upon the skin.

Probably the best operation for a permanent gastrostomy is the method of Janeway, or, as Rheaume has termed it, the Depage-Janeway operation

Depage, in 1901, reported a procedure in which a fistulous tract was formed from a rectangular flap made from the anterior gastric wall with the base at the lesser curvature. This has many obvious advantages over previous methods, but it has distinct disadvantages in bringing the fistulous opening high in the abdominal wall through a region in which the rectus muscle can give but little sphincteric aid, and a further objection is the fixation of the lesser curvature which is physiologically much more important than the greater curvature

The operation of Janeway is as follows: The abdomen is opened in the midline, between the ensiform cartilage and the umbilicus This site for the proposed flap in the anterior wall of the stomach is selected as close to the cardiac end as the stomach will permit, and the surrounding tissues are carefully packed off with moist gauze.

A flap about 2.5 by 5 cm. is outlined. The long axis of the flap is from the greater to the lesser curvatures, with the base on the greater curvature. (Fig. 568.) Two Allis forceps are placed about 2.5 cm. apart, near the lesser curvature of the stomach, marking the free end of the flap. Two other clamps are fastened about 3 cm. apart on the greater curvature outlining the base of the flap. These clamps mark a rectangular portion of the anterior wall of the stomach. An incision is made near the lesser curvature above the two Allis forceps, after securing the vessels that

Fig. 568. Fig. 569.

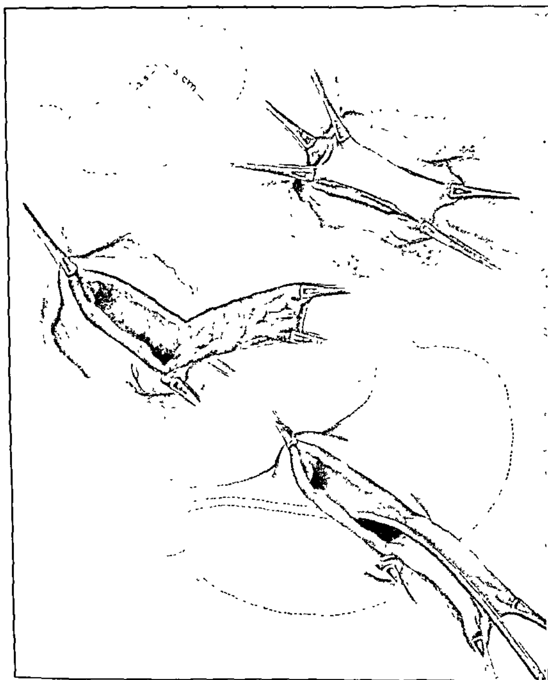


Fig 570 Fig 571.

Fig 568.—Diagram of the stomach showing the outlines of the flap in the Janeway operation

Fig 569.—An incision has been made around the flap except at its base.

Fig. 570.—The flap is turned down and the gastric wound is converted into a triangle.

Fig 571.—A rubber catheter is introduced through the pylorus and rests on the mucosa of the flap.

would be in the line of this incision (Fig. 569). The peritoneal and muscular coats are cut through at first, and then the mucosa is caught and opened with a short incision. The rest of the incision is completed with scissors in order to avoid displacement of the gastric mucosa from the flap. After the flap has been freed except at its base, the Allis clamps used as markers are removed and grasp the whole thickness *of the stomach wall as the flap (Fig. 570). Another Allis clamp is placed* in the middle of the incision along the lesser curvature, and the other clamps in this region are removed.

In the meantime, when the mucosa is first opened, the gastric contents are removed by suction. The bleeding points that have been clamped are secured by transfixing and tying the tissues around them with fine catgut in a needle. The flap is turned down and with one finger in the stomach the pyloric sphincter is located. This can be more readily done by grasping the pylorus with the fingers and thumb of the other hand and shoving it toward the wound. A soft rubber catheter, about No. *10F or 12F, is inserted through the pylorus well into the duodenum (Fig. 571)* and the free end is fastened temporarily to the end of the flap with a clamp.

The wound in the stomach is closed by beginning a continuous suture of fine catgut at the lesser curvature of the stomach, uniting with this line of sutures only the mucosa (Fig. 572). When the suture reaches the base of the flap, it is continued on to the extremity of the flap, still approximating only the mucosa. A second row of sutures of fine chromic catgut brings together the peritoneal and muscular coats (Fig. 573). This suture is tied at the end of the flap, but it is cut long and fastened with a clamp to the rubber tube. A short incision about 2.5 cm. in length is made *through the outer border of the left rectus muscle just below the costal margin* The incision is carried through the rectus muscle in a zigzag manner so that some of the fibers on the right side of the incision are displaced to the left and some on the left are displaced to the right. This appears to increase the valvular action of the rectus. The edges of the sheath of the rectus muscle are firmly caught with clamps, and a large curved Kelly clamp is inserted through the wound into the abdominal cavity. The clamp catches the cut end of the suture and the rubber tube, and, assisted by gentle manipulation from within, draws them and the gastric flap through this short incision (Fig. 574). This constructed gastric channel traverses the abdominal wall with its end on a level with the skin. It is fastened to the anterior sheath of the rectus on each side of the incision by a stitch of chromic catgut which goes only through the serous and muscular coat of the gastric tube (Fig. 575). The gastric mucosa of this channel is attached to the skin with a few interrupted sutures of silk which should not include the muscular or serous layer of the stomach (Fig. 576). The peritoneal cavity is inspected, and, if it seems indicated, a few additional interrupted sutures are placed along the suture line in the stomach.

The midline incision is closed in the usual way The rubber tube, which reaches from well into the duodenum or into the jejunum through the stomach and through this fistulous tract constructed from the wall of the stomach, is carried through the dressings and the abdominal bandage. Adhesive plaster is fastened around it and through this a safety pin is thrust to prevent the tube from slipping out The end of the tube may be clamped with a hemostat or with a clip.

Feeding is begun at once, starting with 30 to 60 c c. every three hours. This is gradually increased, until after a few days 200 to 250 c.c. may be taken at each feeding without discomfort The interval between feedings is increased to four

Fig. 572. Fig. 573.

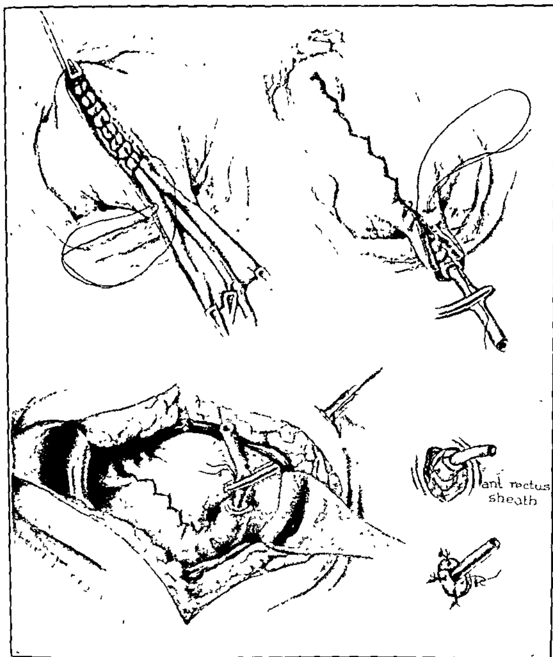



Fig. 574 Figs. 575 and 576

Fig 572.—The tube is fastened to the end of the flap with a clamp The gastric mucosa is being sutured with a continuous lockstitch

Fig 573 —The suture in the gastric mucosa has been completed and the end of the suture caught with a clamp on the end of the tube A layer of right angle sutures buries the first row of sutures in the mucosa

Fig 574 —A Kelly forceps has been introduced through the short wound to the left of the incision. The catheter and the suture are caught in the forceps and drawn through the short wound onto the abdominal wall

Fig. 575 —The external portion of the constructed gastrostomy tube is sutured to the anterior sheath of the rectus muscle

Fig 576 —The gastric mucosa is fastened to the skin with a few sutures.

hours. Water may be supplied through the gastrostomy, or by proctoclysis, hypodermoclysis, or intravenously. The tube is shortened 2 cm. a day until six days after the operation, when it is entirely removed, and then inserted only for feedings.

The feedings, of course, should be liquid so they can be readily introduced, but they may consist not only of milk but of finely suspended foods that can be given through the tube, and should be increased until the total of twenty-four-hour feedings will provide about 2,500 calories.

According to Quick and Martin, in only about 5 per cent of these cases does leakage occur. A small tube, a No. 12F catheter, is better than a larger tube. Not only is there less likelihood of leakage but it is a distinct advantage not to have the food introduced into the stomach too rapidly. The small diameter of the fistula aids greatly in the control of leakage. The sphincteric action of the rectus muscle, which is hardly available when the fistulous opening is made through a wound near the xyphoid cartilage, as in the Depage operation where the immobility of the tissue seems to prevent proper contraction of the rectus muscle, is also helpful in the control of the fistula. The tract can be dilated by the passage of sounds or bougies, so that with a cystoscope in the gastrostomy opening a bougie can be introduced through the stomach into the esophagus. Then, too, if natural feeding is again instituted, this tract may be abandoned almost indefinitely, and later dilated if the dysphagia recurs. This procedure seems to be the best technic for gastrostomy in which it appears probable that feeding through the gastrostomy opening must be permanent.

A modification of the original operation which seems valuable is that, instead of a rubber catheter being introduced through the pylorus into the duodenum, it is *merely placed through the gastrostomy opening into the stomach, thus avoiding con-*siderable unnecessary manipulation which may increase the danger of infection. Then, too, the intestines cannot utilize a too sudden increase in food. The feeding is given into the stomach in small quantities and is increased after a few days.

It is well known that an incision in the midline of the abdomen above the navel is difficult to heal and is prone to break down. It seems possible that a compromise between this short incision as advocated by Martin and Watson and the incision described in the Janeway technic can be effected by making the first incision along the inner portion of the left rectus muscle as long as may be necessary. Then the constructed gastric tube can be brought through a stab wound to the left.

Another type of gastrostomy occasionally employed is that of Jianu This may be used as part of a channel of living tissue through which food can be conveyed from the mouth, as after complete stricture of the esophagus or excision of a cancer of the esophagus. *It is too extensive an operation to be justifiable in inoperable cancer.*

After a resection of the lower esophagus, the lower stump of the esophagus is inverted and buried by a purse-string suture The upper stump is mobilized and brought out through an incision at the root of the neck, and the thoracic incision is closed. Through a transverse cut in the skin of the chest, over the second intercostal space, the upper stump of the esophagus is drawn down after undermining the tissues from this wound to the incision in the neck The wound in the neck is closed A tube connects the stump of the esophagus to the gastrostomy channel.

The steps in the formation of this gastric tube are, first of all, a thorough exposure of the stomach through a long abdominal incision The gastrocolic omentum

is clamped, divided, and tied in sections midway between the colon and the greater curvature of the stomach. The left gastroepiploic artery must be preserved. A long soft-bladed clamp is placed longitudinally on the stomach about midway between the curvatures. On the cardiac portion a shorter soft-bladed clamp meets the longer clamp. In this way the segment of the stomach which is to form a tube is

Fig. 577. Fig. 578.

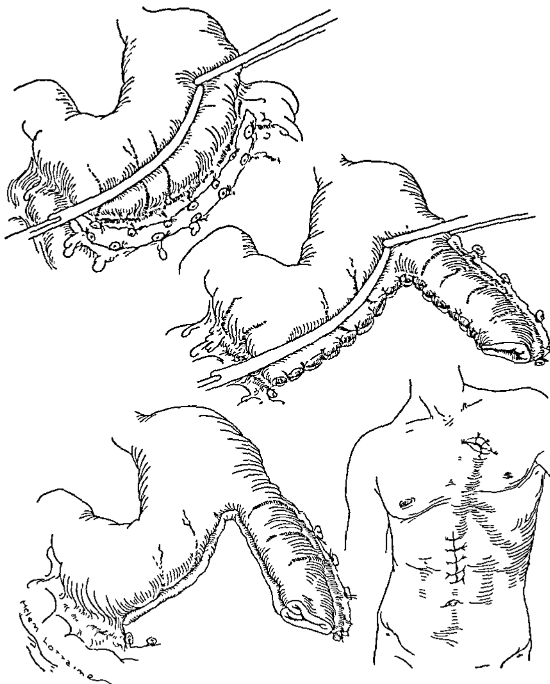



Fig 579 Fig 580.

Figs 577-580.—Diagram showing steps in Jianu gastrostomy.

Fig. 577.—The proposed flap is outlined by soft-bladed clamps The vessels are divided and tied except the left gastroepiploic artery which must be preserved.

Fig 578.—The incision has been made through the body of the stomach for the proposed gastric canal. The first layer of sutures has been placed

Fig 579.—A second row of sutures, burying the inner row, is completed.

Fig 580.—The gastrostomy tube has been brought up through the skin of the upper abdomen and the lower portion of the thorax and is sutured to the incision in the skin.

isolated. The right gastroepiploic artery is clamped, divided, and tied at the pyloric portion of the stomach (Fig. 577). An incision parallel with the greater curvature is made at a sufficient distance from it to insure that the gastric tube be about 2 cm. in diameter after it has been sutured. The blood supply of this tube comes entirely through the left gastroepiploic artery, which must be carefully preserved from injury, else gangrene will ensue. The margins of the flap are sutured with two rows of chromic catgut, the mucosa being united with fine catgut, and a suture somewhat coarser is placed over this (Figs. 578 and 579). A few mattress sutures may be inserted as reinforcement. The gastric wound is closed as in gastrotomy.

The length of the tube is measured, and the point it can reach on the thorax is ascertained. The subcutaneous tissues are burrowed through to this point, and an incision is made over the end of a long forceps. After dilating this tunnel thoroughly, the tube from the stomach is brought through and fastened to the margin of the skin (Fig. 580).

If resection of the esophagus is intended, the gastrostomy should be done some time before the operation on the esophagus, in order that the tissues may become accustomed to the gastrostomy opening and that the patient may be nourished while resting the esophagus. After resection of the esophagus, union of the upper stump of the esophagus to the tube of gastric tissue directly, or by a connecting link consisting of a large rubber tube, can often be effected. A connecting link of a tube constructed from the skin of the thorax, as already described, may be provided. This type of gastrostomy is now very seldom indicated, since other methods of connecting the esophagus to the stomach or bowel, as described in the chapter on the esophagus, are more practical.

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CHAPTER 51

# GASTROENTEROSTOMY; PYLOROPLASTY

Guy W. Horsley

## GASTROENTEROSTOMY

### Indications and General Considerations

It is doubtful whether gastroenterostomy should be considered quite so unphysiologic as it was formerly thought to be. To be sure, the detour that it makes for the gastric contents is abnormal, but it seems obvious that one of the ways in which gastroenterostomy is beneficial is by permitting the regurgitation into the stomach of the alkaline contents of the duodenum whose chief factor of alkalinity is the pancreatic juice. It is now known that normally toward the end of gastric digestion there is a reflux of the duodenal contents into the stomach. This tends to reduce the acidity of the gastric juice and makes it less irritating when ejected onto the mucosa of the duodenum. It would appear, then, that one of the most important functions of a gastroenterostomy is to restore this physiologic regurgitation of the duodenal contents into the stomach, which had been prevented by pyloric obstruction, either functional or organic.

It is well to remember that the chief alkaline constituent of the duodenal contents is the pancreatic juice. Bile is very weakly alkaline and often actually neutral. Any procedure of diverting the bile alone into the stomach does not simulate the physiologic action of regurgitation of the whole duodenal contents including the bile and pancreatic juice. It has been proposed, for instance, that peptic ulcer of the stomach or duodenum be treated by an anastomosis between the gall bladder and the stomach with the expectation that the pouring of bile from the gall bladder into the stomach would lower the acidity of the gastric juice. Bile, of course, normally does not mix with the pancreatic juice until it reaches the duodenum. Owing to the very slight alkalinity of the bile, it could have but little if any effect upon the lowering of the acidity in the stomach; it is the total duodenal content, particularly the pancreatic juice, that is important in this respect. However, even if the bile were strongly alkaline, but little of it would flow through the gall bladder into the stomach if the common duct was normally open. The effect of an acid gastric juice on the mucosa of the gall bladder is irritating, and would produce cholecystitis and probably cholangitis.

Gastroenterostomy is also beneficial in giving rest to the stomach. Physiologic rest—one of the most important of all therapeutic measures—is accomplished by pyloroplasty in properly selected cases, by weakening the resistance of the pyloric sphincter and the muscles of the pyloric canal, so requiring less peristaltic effort in emptying the stomach. This is provided even more abundantly by the stoma of the gastroenterostomy, and the diversion of the gastric current from the diseased tissues gives them added rest.

While obstruction at the pyloric end of the stomach or in the first portion of the duodenum is relieved by gastroenterostomy, obstruction in the terminal duodenum is not markedly benefited by this operation. Another procedure—duodenojejunostomy, to be described later—is indicated here. An extensive inflammation of the duodenum, or duodenitis, a large ulcer in the duodenum that resists medical treatment, mechanical obstruction at the pylorus or at the first portion of the duodenum, are indications for gastroenterostomy. In inoperable cancerous growths of the pylorus with obstruction, gastroenterostomy may be done, though partial gastrectomy is much better unless the growth is quite adherent. Even if there are metastases that cannot be removed, the excision of a large ulcerating obstructing mass in the pyloric end of the stomach by partial gastrectomy makes the patient more comfortable. He is relieved of the toxemia arising from the necrotic infected tumor and is placed in a better condition than would be possible by merely short-circuiting the gastric contents through a gastroenterostomy and leaving the diseased tissue in situ.

One of the chief aims in all operations for the removal and cure of peptic ulcer is to change the conditions under which the ulcer formed. For that reason, a simple excision of a peptic ulcer is frequently followed by recurrence. Occasionally an ulcer well down in the duodenum may be excised with no recurrence. However, simple excision of a gastric peptic ulcer should always be accompanied by either a pyloroplasty or a gastroenterostomy. If the ulcer is along the lesser curvature, excision of the ulcer with a V-shaped triangular mass of tissue deranges gastric peristalsis, and the clinical results are unsatisfactory. Such an excision should be done only when the ulcer is difficult of access or the condition of the patient contraindicates partial gastrectomy.

The formation of a jejunal ulcer after gastroenterostomy is a great problem and will be discussed later, but it may be stated here that it occurs more frequently in cases that maintain a high acidity of the gastric juice after the operation. When a properly executed gastroenterostomy that functions satisfactorily is not followed after two or three months by a markedly subnormal gastric acidity—in other words, if the mixture of the alkaline duodenal contents with the gastric juice in the stomach as established by the gastroenterostomy cannot either eliminate the acidity of the gastric juice entirely or considerably reduce it—it is highly probable that there will be either a recurrence of the ulcer at the original site or the formation of a jejunal ulcer, or both

This type of case is fortunately not very common, but it nevertheless occurs in about 5 or 10 per cent of all peptic ulcers Cushing has shown that these persistent and recurrent ulcers are probably due to excessive stimulus through some cerebral or nervous influence. The additional measure of section of the vagus nerves just below the diaphragm has reduced the incidence of recurrent and jejunal ulcers and made gastroenterostomy a more useful p re.

A partial gastrectomy for a gastr t is accessible f opera-
tion seems to be the proper procedu gastric ulcer th only a
tendency to cancer but often an acco rked gastritis region
of the ulcer. But to remove a large p apparently ach in
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make them white It simulates cicatricial obstruction more closely than any other procedure. If tied tightly enough to crush the mucosa, naturally the advantages of such a ligature are abolished by the injury to the mucosa. The first loop of the knot is held with mosquito forceps to prevent slipping or increasing the tension when the second loop is placed. The kangaroo tendon is tied four times (Fig. 581) and peritoneum-covered fat from the gastrohepatic and the gastrocolic omentum is brought over the knot and fastened with a suture of fine catgut. In this way not only is an occlusion produced, but the danger of necrosis, which might occur if the ligature is tied too tightly, is avoided.

The cure of a duodenal ulcer by gastroenterostomy is probably due to three factors: (1) the introduction into the stomach of the duodenal content with its alkaline constituents, so reducing the acidity of the gastric juice and reproducing the physiologic process in which the pylorus relaxes toward the end of digestion and the duodenal contents regurgitate into the pylorus; (2) partial physiologic rest is given the stomach because of the larger opening without even sphincteric obstruction, which makes expulsion of its contents easier; (3) rest is also given to the region of the ulcerated lesion which may be increased by the kind of pyloric occlusion described. When accompanied by vagotomy, the increased incidence of low acidity insures a higher percentage of good results.

## History

Gastroenterostomy was introduced by Wölfler in 1881. His assistant, Nicoladoni, suggested this operation to Wölfler. This was the anterior gastroenterostomy, and was done with a long loop, which often resulted in severe vomiting, frequently fatal. Von Hacker, in 1885, performed the first posterior gastroenterostomy, uniting the jejunum to the posterior wall of the stomach through an opening in the mesocolon. This operation was also with a long loop, and the results were unsatisfactory. Vomiting and a so-called vicious circle were frequent postoperative complications. In 1885 the mortality from the operation was estimated at 70 per cent. In 1892 this mortality rate had fallen to about 39 per cent. It seems probable that the bad results were due to the kinking or obstruction of either the afferent or efferent loop.

The method of Roux, in which the jejunum was divided, the distal end sutured to the stomach and the proximal end to the jejunum farther down, was supposed to have overcome this vicious circle. The no-loop method or the short-loop method was introduced about 1900. There was for a considerable time a discussion whether the stoma in the stomach and bowel should be isoperistaltic or retroperistaltic in its direction Some surgeons, as Lord Moynihan, have found a vertical opening satisfactory It apparently makes but little difference whether the stoma is isoperistaltic or retroperistaltic. The important point is to have either no loop or a very short loop and to arrange the efferent loop in such a way that there will be no kink or obstruction It is important to place the stoma rather close to the greater curvature. The peristalsis in the distal half of the stomach is active; in the cardiac end the contraction is tonic and, consequently, waves of peristalsis have but little to do with this region The opening in the posterior wall of the stomach should also approach the lesser curvature in order to secure satisfactory emptying. The opening is usually

about 5 cm. in length, sometimes slightly longer. A very long opening, however, may predispose toward a "dumping stomach" in which the food is rapidly expelled and no gastric digestion can occur.

## Sutures and Clamps

The suture material generally used for gastroenterostomy is chromic catgut. Formerly it was thought that the presence of nonabsorbable suture material, as linen or silk, caused jejunal ulcer. The demonstration of a loose linen or silk thread hanging in the margin of the stoma was considered sufficient evidence that it produced the ulcer. It may predispose toward jejunal ulcer when there is a tendency for such an ulcer to form, but even this is not fully proved.

As the suturing can be done as satisfactorily with chomic catgut as with nonabsorbable sutures, it is well to avoid even that small percentage of cases in which nonabsorbable sutures might be one of the factors in the production of jejunal ulcer.

Until a few years ago soft-bladed clamps were rather generally used in a gastroenterostomy. If the clamps are rubber covered and soft, probably but little damage will be done to all of the clamped mucosa, but the pressure of the blades can hardly be equal along the whole band of clamped mucosa, and this delicate tissue may be injured at some point. The use of clamps facilitates the suturing, prevents a flow of gastric or jejunal contents into the wound, and temporarily checks the bleeding. These advantages, however, would seem to be more than offset by the disadvantages of clamps. When the patient is fat, and the mesocolon short, considerable traction is necessary to deliver the posterior wall of the stomach through the mesocolon and more trauma results in applying the clamps than would be necessary for the exposure of a sufficient amount of the posterior wall when no clamps are used. Even a slight injury to the gastric or jejunal mucosa may give trouble later. The control of bleeding is not so accurate as when the vessels are cut and secured without the tourniquet effect of the soft-bladed clamps. A minor objection is that in suturing the gastroenterostomy with clamps the compressed tissues are deprived of their blood supply during the performance of the operation, and while this vascular deprivation does not last more than a half hour, it certainly cannot be claimed that it helps in the healing afterward.

If, then, the more difficult cases of gastroenterostomy, in fat individuals with small stomachs, can be better managed by tractor sutures without soft-bladed clamps, it would seem logical to adopt this technic for the simpler cases in which soft-bladed clamps are more readily applied Certainly when the effects of trauma to the mucosa from the clamps with the resulting possibility of jejunal or gastrojejunal ulcers are considered, every reasonable precaution to prevent such a sequel should be taken

## Posterior Gastroenterostomy

The abdominal incision used is either a right rectus or one of the upper transverse incisions and should be sufficiently ample to afford easy inspection of the stomach, duodenum, and adjacent viscera. The transverse colon is lifted upward and to the right, to make the mesocolon taut. The jejunum is recognized as it comes out from the mesocolon. If the hand sweeps gently across the base of the taut mesocolon, the origin of the jejunum is readily identified. It is picked up about

7.5 cm. from its origin. There may be a fold of peritoneum from the mesocolon to the jejunum, and if it extends well down onto the jejunum it should be divided. Just above where this fold joins the mesocolon is a bloodless area in the mesocolon which is opened and the posterior wall of the stomach is exposed. If the patient is very fat, the vessels of the mesocolon may be difficult to recognize, and appear to run at the bottom of small grooves in the fat. It is important to avoid injury to the large vessels of the transverse mesocolon, as this may result in gangrene of the colon. An incision to expose the stomach should not impinge upon the close vicinity of these large vessels.

Fig. 581. Fig. 582.

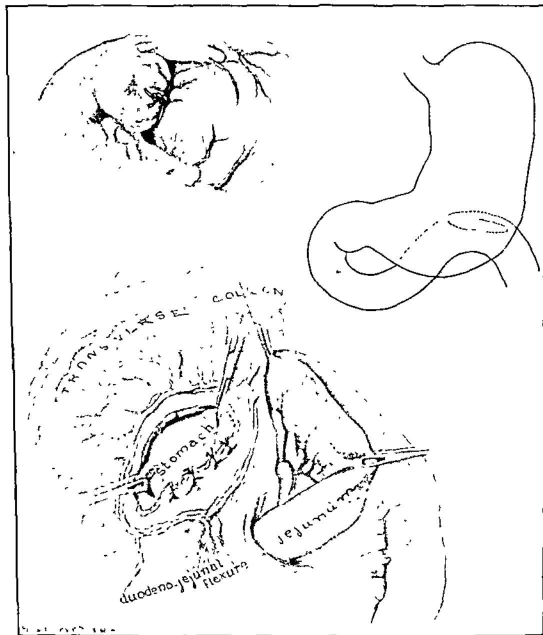



Fig. 583

Fig. 581.—Kangaroo tendon is tied around the pyloric end of the stomach just tightly enough to occlude the lumen of the pylorus. This is done in cases without duodenal obstruction.

Fig. 582.—Diagram of posterior gastroenterostomy.

Fig. 583.—A portion of the posterior wall of the stomach has been delivered through the mesocolon and sutured to the posterior border of the rent in the mesocolon.

A considerable portion of the posterior gastric wall is drawn through this opening. This procedure is facilitated by pushing the stomach through the opening with the left hand on its anterior surface while pulling on the posterior surface from below. The site for the gastroenterostomy is about on a line with the esophagus (Fig. 582).

Following the suggestion of McArthur, the posterior margin of the rent in the mesocolon is now sutured to the upper portion of the posterior wall of the stomach with a few interrupted sutures of fine catgut. This is done at this stage of the operation, when the tissues are easily accessible. This suturing is to avoid the possibility of a hernia of the small intestine into the lesser peritoneal cavity, which was a not infrequent sequel in the early days of gastroenterostomy before this precaution was taken (Fig. 583).

The proposed stoma in the stomach is outlined by Allis forceps, and forceps are also placed on the jejunum. To avoid confusion in the direction of the jejunum, Allis forceps are fastened at the upper end of the proposed incision in the jejunum and mosquito forceps lower down. The alphabetical sequence of the two instruments makes it easy to remember that the Allis forceps is above and the mosquito forceps below.

At a point about 7.5 to 10 cm from the origin of the jejunum, where the Allis forceps is placed, a suture of 00 chromic catgut is inserted from the jejunum to the posterior wall of the stomach near its middle, approaching the lesser curvature. A second suture, placed about 7.5 cm. farther down, unites the jejunum to the posterior wall of the stomach near the greater curvature and somewhat to the left of the preceding suture. These tractor sutures in the jejunum should be placed not at a point directly opposite the mesentery, but on what might be called the upper surface of the jejunum, near the free border. If placed opposite the mesenteric border, by the time the suturing of the gastroenterostomy has been completed it will be found that the last row of anterior sutures is too near the lower mesenteric attachment of the jejunum. In order to avoid this, the incision is made somewhat to the upper mesenteric side of the border opposite the mesentery. Such an incision gives ample room for the suturing of the anterior surface of the gastroenterostomy, where more tissue is turned in than from the posterior surface The position of the tractor sutures in the jejunum fixes the location of this incision and of the stoma which should extend from near the middle of the posteror wall of the stomach obliquely downward and to the left.

After packing around the tissues with moist gauze, these two tractor sutures are wrapped around a Lang's loop frame under some tension This automatically brings the tissues to be sutured into two slight adjoining ridges. Beginning on the right, a continuous right angle suture of 00 chromic catgut unites these ridges. The short end of the knot is caught with hemostatic forceps This suture can best be applied with a thin large curved needle It is drawn rather snugly and an occasional backstitch is taken to lock the sutures With the tissues under some tension from the tractor sutures, the continuous suture is applied more tightly than if the tissues were relaxed, for when the tractor sutures are loosened there is less pressure by the continuous suture which is thereby shortened (Fig 584). This suture approximates about 7.5 cm. of the jejunum to the stomach. When the left end is reached, it is locked by a backstitch and temporarily discontinued The frame to which the tractor sutures are attached is lifted up and moist gauze is packed beneath it. This

elevates the stomach and lessens the tendency of the gastric contents to escape. An incision is then made in the stomach opposite the middle of this row of sutures, and about 0.5 cm. from it. It should be not more than 1.5 cm. in length at first, and is carried through the whole thickness of the stomach wall (Fig. 585). The larger vessels that are apparent are clamped before they are cut. As soon as the gastric mucosa has been incised, an aspiration tip is introduced and the remaining gastric con-

Fig. 584.

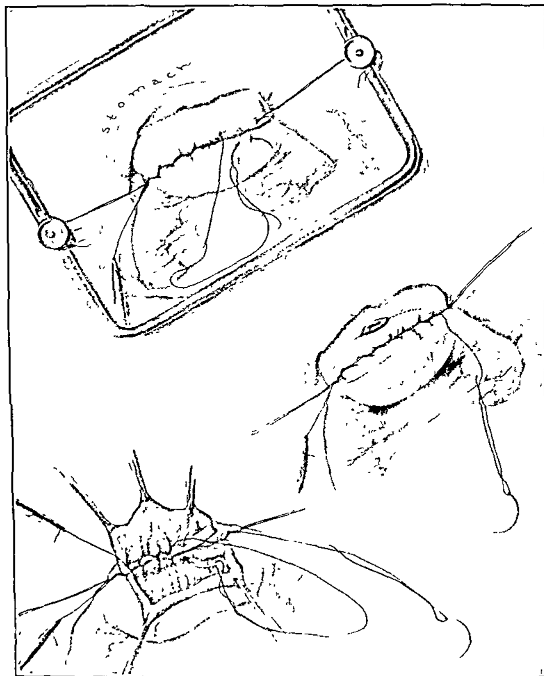



Fig. 585 Fig 586

Fig 584 —Two tractor sutures have been placed and fastened around Lang's metal frame The jejunum is being sutured to the stomach with a continuous mattress or right angle suture

Fig 585 — An incision about 1.5 cm long is made in the stomach through all its coats

Fig. 586 — The posterior margin of the wound in the stomach is sutured to the posterior margin of the wound in the jejunum with a continuous lockstitch.

tents are drawn off. It should be noted here that all cases prepared for gastric surgery should have the gastric contents aspirated before the anesthesia is started and the tube left in place so that they can be again aspirated just before the stomach is opened. All bleeding vessels are clamped.

The incision in the stomach is extended with scissors, cutting about 1.5 cm. at a time and clamping the vessels with small Ochsner forceps as they are divided. The total incision in the stomach is about 6 cm. long. If the stomach is markedly dilated, the incision should be about 7.5 cm. long because there will be contraction later on. A similar incision is made in the jejunum. The margins of the wound in the jejunum are caught with small hemostatic forceps.

Such an opening, if properly placed, is amply large. Certainly the jejunum cannot transmit a bolus of food larger than its diameter, and there is no need of a stoma which, after allowing for late contraction, is larger than the diameter of the jejunum. The diameter of the duodenum as it joins the pylorus is physiologically sufficient, and it is even smaller than the diameter of the jejunum at the point of anastomosis. If huge openings are made in the stomach they serve no useful purpose and may promote a "dumping stomach" and retard or prevent any action of the gastric juice upon the food in the stomach. It has been shown rather conclusively by experimental work that pure concentrated gastric juice has a very irritating effect upon the mucosa of the small intestine and is a potent cause of peptic ulcer. If the food empties quickly into the jejunum, it means that there will be a long interval in which the jejunum must be subjected to the pure gastric juice.

Beginning on the right side, a suture of chromic catgut firmly unites the posterior margin of the wound in the stomach to the posterior margin of the wound in the jejunum. The short end of the knot is clamped. The suture is continued as a lockstitch (Fig. 586). If jejunal or gastric contents tend to well into the wound, they are removed by suction. The hemostatic forceps on the posterior margin of the wound in the stomach and on the posterior margin of the wound in the jejunum are lifted up, so making a flange easily accessible as the suture proceeds. Each stitch is locked snugly, and where a forceps clamps a blood vessel an extra loop of the suture is placed to insure hemostasis. This suture line is reinforced with two or three interrupted sutures

When the left end of this wound is reached, the suture is continued anteriorly and inserted in such a way as to maintain somewhat the same effect of infolding the tissue and securing hemostasis as in the posterior suture. It is first locked by a backstitch at the left end of the wound and then is thrust through the jejunum from the mucosa to the peritoneal surface, and through the stomach from the peritoneal surface to the mucosa. It is drawn snugly as it emerges from the gastric mucosa, while with the thumb or finger of the other hand pressure is made just behind the suture. In this way, the margins of the wound are inverted. Often two sutures are taken before they are drawn taut, but they should not be tightened until the needle emerges from without inward on the gastric mucosa. When a forceps clamping a vessel is met, an extra loop of the stitch is placed and it is well to take a backstitch occasionally in order to lock the line of sutures. It is not practicable to make a continuous lockstitch as in the posterior wall, but in other respects this suture is somewhat similar in its effect (Fig. 587). When the starting point of this suture is reached, the thread is tied to the original knot.

During the application of this suture the mucosa is sponged with moist gauze, but this is done gently and with a patting motion, instead of wiping, as the mucosa is very sensitive to trauma and any unnecessary injury may be the beginning of an ulcer. It has been claimed by some that the pressure of clamps on the delicate mucosa of the jejunum or stomach is a predisposing cause of peptic ulcer. Certainly rough handling and rough sponging of this delicate mucosa can produce sufficient trauma for an ulcer.

The line of sutures is watched as it is being applied to see that all bleeding is controlled. When the suture is tied to its original knot, hemostasis at all points should be complete. If for any reason there is an oozing spot along the suture line, it is whipped over with a suture of catgut. In order to secure hemostasis in this vascular tissue it is quite necessary to apply the suture snugly enough to control bleeding. Many years ago in experimental work Mall and Halsted showed that the margins of the mucosa in sutured intestine became necrotic and separated or were absorbed. It is certainly true that if sutures are applied to the margins of the wounds in the stomach and jejunum snugly enough to effect hemostasis, necrosis of these margins will result. As the necrotic tissue separates from the living tissue, a line of comparatively uninjured mucosa remains.



Fig. 587. Fig. 588.

Fig 587.—This suture reaches the left end of the wound and is continued anteriorly and drawn snugly as it emerges from the gastric mucosa while pressure is being made on the sutured wound This tends to invert the margins of the wound

Fig. 588—The first row of sutures is carried anteriorly as a continuous right angle suture with an occasional backstitch.

After cleaning the line of sutures gently with gauze soaked in salt solution, the original 00 chromic catgut continuous right angle suture is again taken up and carried anteriorly as a right angle continuous suture with an occasional backstitch (Fig. 588) It is tied to its original knot. When a gastrostomy and transgastric jejunostomy are used, the catheters are placed through the anterior gastric wall and sutured in place before the anterior anastomosis is completed. The tractor sutures are loosened, and another row of 00 chromic catgut sutures with an occasional backstitch is placed anteriorly. This makes three rows of sutures placed anteriorly with two rows posteriorly As the anterior row of sutures is doubtless subjected to more strain

than the posterior, and as the inner row of posterior sutures is applied somewhat more securely than the inner row of anterior sutures, this additional reinforcement seems advisable. At each end of the stoma the jejunum is sutured to the stomach with a mattress suture of 00 chromic catgut. This is done in order to prevent too sharp kinking of the afferent or the efferent portions of the bowel. The tractor sutures are cut.

When the suturing is completed, there should be a very short loop of jejunum on the oral side of the anastomosis, not sufficient to sag down markedly but presenting a gentle curve. In this way there is room for subsequent contraction of the stomach without too much tension on the jejunum. If the anastomosis is too close to the origin of the jejunum, without allowing an interval of 5 or 10 cm. between it and the stoma, contraction of the stomach later on may make dangerous tension on the sutures.

The anterior surface of the rent in the mesocolon is fixed to the stomach about 1.5 cm. above the gastroenterostomy with interrupted sutures of 00 chromic catgut. In this way the stomach is held down well below the mesocolon, and if the opening in the mesocolon later contracts, the line of pressure will be on the stomach side of the stoma and not directly on the stoma itself. The jejunum is replaced in the abdomen, care being taken to make its efferent loop from the stoma lie toward the left side so that it will not be kinked. During the few hours in which there is paresis of the intestine following the manipulations of the operation, the efferent loop may become lightly adherent to the neighboring structures, and when peristalis is reestablished some obstruction may result if it is not properly placed.

If it is desired to use rubber-covered soft-bladed clamps, this can be done with the technic described up to the point of inserting the tractor sutures. The incision is made in the transverse mesocolon, the posterior wall of the stomach is delivered through this incision, the proper site for the proposed stoma is chosen, and the posterior margin of the rent in the mesentery is sutured to the posterior wall of the stomach, leaving an ample amount of stomach for the application of the soft-bladed clamps. No tractor sutures are needed. The clamp is applied on the stomach first, and in the direction of the proposed stoma. Then a loop of jejunum is selected about 7.5 cm from its origin, and a soft-bladed clamp is placed on it. The two clamps are fastened together by placing a hemostatic forceps on the rubber tubes covering them. The old Roosevelt clamp, consisting of three blades, was formerly rather popular It has but slight advantage over the separate clamps, and there is a possibility of greater trauma to the mucosa because of the middle unyielding blade onto which both the stomach and jejunum are pressed. The larger vessels should be ligated. The suturing otherwise is accomplished in much the same way as described in the operation without clamps

When it was formerly the custom to use a continuous mattress stitch as the inner row on the anterior margin of the gastroenterostomy, because the margins of the wound could thereby be neatly inverted, postoperative bleeding not infrequently occurred. With a continuous mattress or right angle suture the tissue opposite a loop of this suture is but slightly compressed. In this way approximately half of the wound had but little if any compression by the sutures. When, however, the suturing is applied as a continuous lockstitch, or as a continuous running suture with an occasional lockstitch or backstitch, equal pressure is made along the entire margin of the wound and secondary bleeding is avoided.

## Anterior Gastroenterostomy

Anterior gastroenterostomy may be indicated when adhesions prevent ready access to the posterior wall of the stomach. When the transverse mesocolon is extremely short, Francis Mathews does a posterior gastroenterostomy by opening the gastrocolic omentum instead of the transverse mesocolon, bringing the jejunum over the colon and attaching it to the posterior wall of the stomach. Naturally, in such a case, the loop of the jejunum must be somewhat longer than when a posterior gastroenterostomy is done in the usual manner.

When an anterior gastroenterostomy becomes necessary, a much longer loop of jejunum is used. Since there is often postoperative swelling and congestion, the loop should be ample in order to avoid subsequent tension. In anterior gastroenterostomy clamps can be used on the jejunum and also on the stomach, but it is even easier to do this operation without clamps than a posterior gastroenterostomy. The suturing is quite similar to the suturing of a posterior gastroenterostomy. Tractor sutures are placed from the loop of jejunum that has been selected for the stoma to points near the greater curvature of the stomach, because when a patient is in bed, or even after he is in the erect position, the lower posterior gastric wall is more dependent than the anterior wall. While the normal stomach empties by peristalsis, the point usually selected for an anterior gastroenterostomy is near the beginning of the peristaltic waves where they are weak and where propulsive power is largely from the tonic contraction of the cardiac end of the stomach. Consequently, gravity in this region of the stomach is much more important than in the pyloric end where peristalsis is the chief factor in emptying and gravity plays but little part.

In order to prevent traction on the line of sutures a few additional interrupted sutures should be placed not only at the ends of the gastroenterostomy stoma, but also along the upper suture line.

An enteroanastomosis is frequently necessary after an anterior gastroenterostomy. If this is not done, the proximal end of the jejunum may find some difficulty in discharging its contents, and obstruction may result. The enteroanastomosis is made about where the loops of bowel cross the transverse colon. The opening need not be large, because it is not intended to divert all of the duodenal contents through this enteroanastomosis but only a sufficient portion to prevent distention. An opening of 2 5 cm. or 3.75 cm. is sufficient. This will doubtless subsequently contract somewhat.

Some surgeons suggest placing one of the halves of a small Murphy button into each limb of the jejunum before the inner anterior row of sutures in the gastroenterostomy is completed, and so directing them that they can be cut down upon and clamped together where the bowel crosses the transverse colon. The occasional uncertainty, however, of the action of a Murphy button, and the impossibility of determining whether it may by its weight act as an anchor and cause some disturbance, seem to make the suture method more desirable, even though it takes longer.

The two loops of jejunum are united with a continuous suture of chromic catgut for a distance of about 5 cm. Clamps may be applied. There is not the same objection to them here as there would be in a gastroenterostomy so far as causing a peptic ulcer is concerned, because this region will necessarily be amply protected by alkaline duodenal contents. The chief danger is that too much of the

duodenal contents will be diverted and not enough delivered to the site of the gastroenterostomy to prevent the irritating effect of the gastric juice at that stoma.

After applying the sutures an incision about 2.5 cm. long is made in both loops of bowel, the contents are sponged out or removed by suction, and the margins of the incisions are caught with hemostatic forceps. A second row of sutures is placed, using silk as a continuous lockstitch or as an interrupted suture, uniting the posterior margin of one wound to the posterior margin of the other. The first row of sutures is taken up and applied as a continuous right angle stitch with an occasional backstitch and tied to its original knot. As these tissues are readily accessible, the suture may be used in a straight needle, though when the opening is small frequently a curved needle will be found more suitable. In intestinal anastomosis the inner suture is always silk, while catgut is frequently used for the outer suture.

### The Gastroenterostomy of Roux

The gastroenterostomy of Roux, or the *en Y* method, may occasionally be indicated. The indications for it are the presence of adhesions and the inaccessibility of the portions of the gastrointestinal tract that are ordinarily utilized in a gastroenterostomy. This type of gastroenterostomy has an extremely limited field. It has been quite definitely proved by Mann and his associates at the Mayo Clinic—and Dragstedt and Matthews and others have confirmed those findings—that so-called surgical drainage of the duodenum in dogs is almost invariably followed by peptic ulcer. Surgical duodenal drainage, as has been explained, consists in severing the duodenum at its junction with the pylorus, dividing the jejunum well below its origin, attaching the distal end of the jejunum to the pyloric end of the stomach, closing the duodenum, and suturing the proximal end of the jejunum to the ileum. In this way the alkaline contents of the duodenum are diverted from the small bowel that joins the stomach, and peptic ulcer results near the junction of the jejunum to the stomach.

Doubtless this gastroenterostomy of Roux in man would be followed more consistently by ulcer if there was no regurgitation of the duodenal contents up from the jejunum.

According to the technic of the *en Y* or Roux operation, the stomach is exposed as in a gastroenterostomy through an opening in the transverse mesocolon. The posterior margin of the rent in the mesentery is sutured to the posterior wall of the stomach, as described in posterior gastroenterostomy, with interrupted sutures of catgut. If adhesions or some other lesion renders the posterior route impossible, the *en Y* type of gastroenterostomy may be done anteriorly A point in the jejunum is selected so there will be an ample length of bowel for the manipulation of this operation, and so there will be no tension. About 20 cm below its origin the jejunum is doubly clamped and divided, the mesentery of the jejunum being also incised for a short distance. The distal end of the jejunum is sutured to the posterior wall of the stomach, first with a row of 00 chromic catgut sutures that approximates the peritoneum and the mesentery of the jejunum to the posterior wall of the stomach (Fig. 589) An incision about 5 cm. long is made in the stomach, and an inner row of sutures is applied after the manner described in a posterior gastroenterostomy, beginning on the right side, and uniting the posterior margin of the wound in the stomach to the posterior margin of the end of the jejunum When the left extremity of the wound is reached, the suture is continued anteriorly

as in gastroenterostomy and tied to its original knot. The first row of sutures is carried anteriorly and buries the inner row of sutures. This is reinforced by another anterior row of sutures. The anterior portion of the rent in the mesentery is sutured to the stomach, as described in posterior gastroenterostomy. The proximal end of the jejunum is united to the side of the jejunum about 15 cm. below the gastroenterostomy opening, in a somewhat similar manner as the end of the jejunum is sutured to the stomach. Two rows of sutures are used as described in the enteroenterostomy following an anterior gastroenterostomy, with a few interrupted mattress sutures for further protection of the wound. Too much tissue, however, should not be turned in, for this may produce an obstruction.



Fig. 589.—The *en Y* or Roux gastroenterostomy The jejunum has been divided about 15 to 20 cm below its origin, the distal end is sutured to the posterior wall of the stomach, and the proximal end is united end to side to the jejunum lower down This operation seems peculiarly liable to be followed by jejunal ulcer.

## Gastroenterostomy in Infants

Very rarely is it necessary to do a gastroenterostomy in an infant, such as upon babies that have a congenital absence or an occlusion of a portion of the duodenum. The regular technic of gastroenterostomy in an adult must be modified in an infant. The intestines are small, about the size of an ordinary earthworm, and the stomach is moderately distended. The gastrocolic omentum and the transverse mesocolon in such cases are quite thin. It is not necessary to incise the mesocolon and draw the stomach through the opening, for the mesocolon is transparent and may be treated as though it were a layer of peritoneum over the stomach (Fig. 590).

Fine silk in a small curved needle is the best suture material for these cases. Two tractor sutures are placed between the loop of jejunum that it is proposed to unite to the stomach, and the posterior wall of the stomach, and are clamped and held taut.

On account of the small size of the intestines, too much suturing is undesirable, so instead of inserting a preliminary continuous suture between the jejunum and stomach before incising the stomach and jejunum, the incision is first made, and a row of silk sutures placed as a continuous lockstitch and drawn snugly is the only suturing used posteriorly. This line of sutures, accurately placed, is safe. When it is brought anteriorly, however, there is some difficulty in making as smooth a union as in the posterior wound, so an additional row of sutures is inserted anteriorly and this, if necessary, is reinforced by a few interrupted mattress sutures of fine silk.

On account of the active peristalsis of the stomach and intestines, and the possibility of rapid absorption of catgut, together with the fact that the danger of the use of silk in the stomach is generally much overrated, silk is used in these cases.

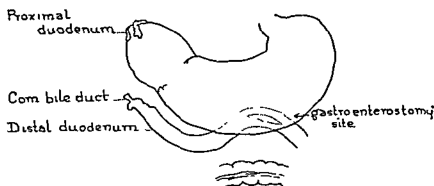



Fig 590—Outline of the congenital deformity in an infant six days old, referred to in the text

It is highly important that there be no obstruction to the afferent or efferent loop. The lumen of the bowel is so small that an obstruction could easily occur. Using only one row of sutures posteriorly lessens such a possibility. Frequently it is desirable to make this anastomosis in these small babies over a small 12 or 14F catheter, leaving one end in the stomach and passing the distal end well down into the jejunum This will make the anastomosis easier to perform and will insure earlier emptying of the stomach into the small bowel

A former distressing complication of gastroenterostomy was the so-called vicious circle, when the patient began to vomit soon after the operation. It was supposed to be due to the pouring of duodenal contents into the stomach through the stoma of the gastroenterostomy and the return of this material to the duodenum through the pylorus It is really caused by an obstruction either in an afferent or efferent portion of the jejunum near the stoma which was promoted by a long loop of jejunum on the oral side of the gastroenterostomy. It is prevented by improving the technic so that now only a short loop is made between the terminal duodenum and the stoma, and the jejunum is sutured to the stomach in such a manner that the efferent loop will have no kink or obstruction.

This type of vomiting is now rare, and when it occurs after a properly performed gastroenterostomy, it is usually due to kinking of the efferent loop that has

become stuck to some raw surface by lymphatic exudate. If, after thorough gastric lavage at short intervals, there is no tendency toward relief, the abdomen should be opened and the obstruction corrected.

## PYLOROPLASTY

Pyloroplasty is a term often used as synonymous with gastroduodenostomy. It is a procedure in which the pylorus is altered. The indications for pyloroplasty are usually peptic ulcer or its results and occasionally external constricting bands.

The Heineke-Mikulicz operation, proposed in 1886-1887 by Heineke and Mikulicz, is an incision through a stenosis of the pylorus, sutured transversely. The operation at first was done solely as a plastic procedure to correct a stricture and was not intended as a treatment for an active ulcer.

A pyloroplasty is but seldom used now. If the stenosis is quite extensive and the strictured area almost completely occlusive, an incision across it will be in pathologic tissue, with clinical results that are often bad. Either the stricture may recur no matter how widely it has been divided, or there may be a recurrent ulcer along the margin of the sutured incision. Then, too, cicatricial tissue is difficult to suture and if the incision is made sufficiently long into the duodenum to reach healthy tissue, the union of the duodenum to the thick stomach wall or to the adjacent scar tissue is a procedure of doubtful wisdom. As a matter of fact, when there is marked cicatricial contraction in the pylorus or first part of the duodenum, and it is not malignant, the conditions are most favorable for a posterior gastroenterostomy which gives its highest percentage of successful results in just such cases.

Jaboulay's operation is a true gastroduodenostomy in which the second portion of the duodenum is incised and sutured to an incision in the adjacent stomach. The lesion at the pylorus is not touched. Gastroduodenostomy may occasionally find application even with a marked pyloric stricture, but there is often a subacute inflammation in the tissues adjacent to the stricture which the operative trauma might arouse. As has been said, posterior gastroenterostomy gives such splendid results in just this type of cicatricial contraction that, to justify their use, other procedures must show marked superiority over posterior gastroenterostomy for cicatricial stenosis of the pylorus or duodenum.

The pyloroplasty of Finney doubtless has the widest application of any of the pyloroplasties. When the lesion in the duodenum can be readily excised, when the adhesions are not too extensive, when the duodenum and pylorus can be easily mobilized, or when the cicatricial band is narrow, this pyloroplasty will give satisfactory results and in the presence of adhesions is better than any other type of pyloroplasty; though when adhesions are extensive even this operation should probably give way to a posterior gastroenterostomy.

The first and most important point in the pyloroplasty of Finney is the mobilization of the duodenum The upper border of the duodenum near the pylorus and sometimes the pylorus itself are freed from their upper attachments and from the veillike supporting ligament between them and the undersurface of the liver. A small incision is made along the duodenal margin. If there is fixation from a short hepaticoduodenal ligament, the rounded lateral edge of this ligament is grasped between the thumb and forefinger in order to exclude any important structures and is then carefully divided for about 1 cm. The transverse portion of the duodenum

is further mobilized, directing the mobilization posteriorly. Finally, the descending portion of the duodenum is freed. The entire blood supply of the descending duodenum enters from the median side, and the embryologic fusion of the posterior surface of the two peritoneal layers under the descending duodenum forms an area that is practically avascular and can be readily separated. The transverse, or first, portion of the duodenum having been mobilized, the descending part is freed externally by a superficial incision through the peritoneum that lies lateral to the duodenum. Blunt dissection is then carried behind and toward the midline. The duodenum is rolled to the left in contact with the stomach. The duodenum is attached to the gastrohepatic ligament which has already been loosened by the incision, and retroperitoneally where the flexure of the transverse colon goes over the duodenum. The blunt dissection, which continues along the plane of cleavage toward the median line and behind the lower part of the duodenum, readily mobilizes this lower portion.

When the pylorus and the duodenum have been well freed, three guide sutures are placed as markers and retractors. One is at the upper border of the pylorus, another in the anterior wall of the stomach near the gastrocolic omentum and about 7.5 cm. below the pylorus, and a third is in the free border of the duodenum opposite the suture in the stomach (Fig. 591). When slight traction downward is made on the last two guide sutures, while the pylorus is supported by traction upward, the duodenum and stomach are brought together for the introduction of sutures. There is no occasion for the use of intestinal clamps. Finney used interrupted mattress sutures of silk, first inserting a posterior row and tying them, and then inserting an anterior row, leaving them untied and retracting them. A horsehoe-shaped incision is made parallel with the posterior row of sutures through the stomach, pylorus, and duodenum. An internal row of sutures is placed posteriorly to control the bleeding. (Fig 592.) Finally, the anterior row of mattress sutures is tied. All sutures are of interrupted silk except the internal row of posterior sutures which is of catgut. There is only one row of sutures anteriorly.

Finney suggested that the operation may be performed throughout with continuous sutures and frequently with only catgut sutures

If an ulcer is on the anterior wall of the duodenum, it is readily excised; if it is on the posterior wall, it is somewhat more difficult to excise, but this may be accomplished by removing a triangular piece of the duodenal wall, including the ulcer.

This operation as practiced by Finney gives excellent results when the proper indications for the operation have been observed. The most important point in the operation is thorough mobilization of the duodenum and the pyloric end of the stomach If this cannot be done, the operation should not be attempted.

A pyloroplasty described in 1919 by J. Shelton Horsley was termed "physiologic" because it seems to have the advantage of removing an ulcer in the first part of the duodenum and restoring the physiologic function of the stomach to normal, without any undue mutilation. The incision is a straight incision, two-thirds of which is in the stomach and one-third in the duodenum. It should never be carried farther than 2 5 cm. into the duodenum, and the proportion of the incision in the stomach should always be at least twice as long as in the duodenum. The pyloric canal is about 3 cm long, and this at least should be divided.

The object of the Horsley pyloroplasty is to remove an ulcer and to give physiologic rest to the stomach by dividing the pyloric sphincter and the adjacent pyloric

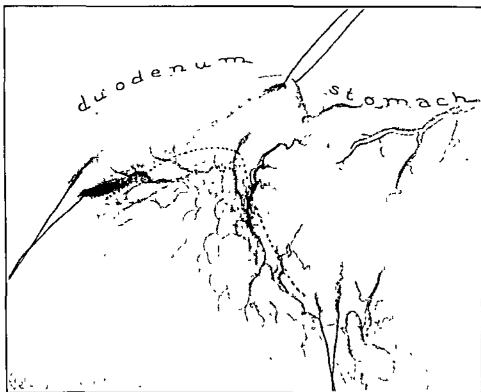



Fig 591.—The first stage of the Finney pyloroplasty. The duodenum has been mobilized. Tractor sutures are placed, as described in the text, and the incision is made along the dotted line.

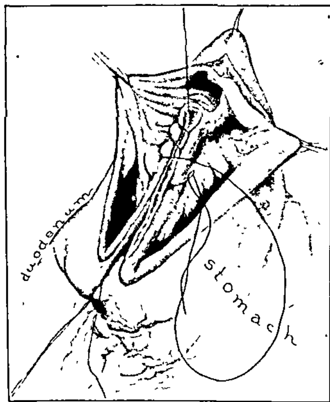



Fig 592—Finney uses a mattress suture of silk, and ties the second row after the incision has been made. The drawing represents a slight modification in which the inner posterior row of sutures is being placed in such a manner that the mucosa of the stomach is not included in the suture, as described in the text. The outer posterior row is a continuous suture

canal. It embodies the same principle that is adopted when the sphincter ani is divulsed or divided for the cure of an ulcer within its grasp. While the operation has a limited field, it still has definite indications, chiefly in the small group of cases in which there is a duodenal ulcer in the first part of the duodenum, without adhesions and without surrounding infiltration, that has resisted the therapeutic efforts of carefully applied medical treatment. Most ulcers of this kind can be cured by medical treatment consisting largely of the proper regulation of diet with the administration of antispasmodics, vagi depressants, and/or alkaline powders. In spite of the best medical treatment, however, a few patients are seen with small limited duodenal ulcers without adhesions, who still have annoying symptoms from the ulcer.

If the adhesions are very limited and only to the gall bladder, the gall bladder may be removed at the same time the pyloroplasty is done and the Horsley pyloroplasty will usually give good results. If, however, the adhesions are extensive and if there is subacute inflammation around the ulcer, as a duodenitis, this pyloroplasty is not so satisfactory and frequently is followed by a recurrence of symptoms.

It is not necessary to mobilize the duodenum in this pyloroplasty, but the incision should never be farther than 2.5 cm. into the duodenum. After packing off the surrounding tissues, a point on the stomach about 5 cm. from the pylorus and midway between the greater and lesser curvatures is caught with Allis forceps. The stomach and duodenum are surrounded with moist gauze and an assistant using his fingers covered with gauze as retractors draws the body of the stomach toward the left, so facilitating the exposure. The length of the incision into the stomach depends upon the location of the ulcer. The incision in the stomach must always be at least twice as long as the incision in the duodenum, and in the duodenum it should never be more than 2.5 cm. Consequently, if an ulcer is more than 2 cm. from the pylorus, this pyloroplasty should not be done. If the ulcer in the duodenum adjoins the pylorus, an incision in the duodenum of 1.5 cm may be all that is necessary, so the incision in the stomach will be 3 cm. in order to divide all of the fibers of the pyloric canal.

The incision is made down to the submucosa of the stomach but not through the mucosa at first. The bleeding points are carefully clamped (Fig 593). The mucosa of the stomach is incised. Great care is taken not to clamp the mucosa of the stomach. The gastric and duodenal contents are emptied by suction The incision is then carried with scissors through the pyloric sphincter; here bleeding vessels are encountered which should be clamped. By keeping the field as dry as possible with suction and sponging with moist gauze wrung out of salt solution, the ulcer can be readily located (Fig 594) If there is a tendency for the gastroduodenal contents to regurgitate into the wound, a moist gauze pack is placed in the stomach and a small strip of moist gauze in the duodenum However, with the frequent use of suction and a watchful assistant this is usually not necessary.

If an ulcer is on the posterior wall of the duodenum or the pylorus, and is quite limited, it may be cauterized, excised, and sutured. If extensive, however, the pyloroplasty should be abandoned and either a partial gastrectomy or a posterior gastroenterostomy should be done.

The anterior ulcer is removed along with a small amount of surrounding healthy duodenal mucosa Bleeding in the wall of the duodenum is controlled with hemostatic clamps No effort is made to separate the mucosa of the duodenum from the rest of its wall, because it would be anatomically difficult to do and be-

cause, too, it does not appear that trauma to the duodenal mucosa is so provocative of ulcer as trauma of the pyloric mucosa. A tractor suture is placed and begins at the extremity of the incision in the stomach, passing through the serous and muscular layers only. The pyloric mucosa should not be grasped even with forceps. At the duodenal extremity the suture penetrates the whole of the duodenal wall (Fig. 595). About 1.5 cm. above this, another tractor suture is similarly passed, taking care to avoid injury to the pyloric mucosa. The sutures are of 0 chromic catgut. These

Fig. 593. Fig 594

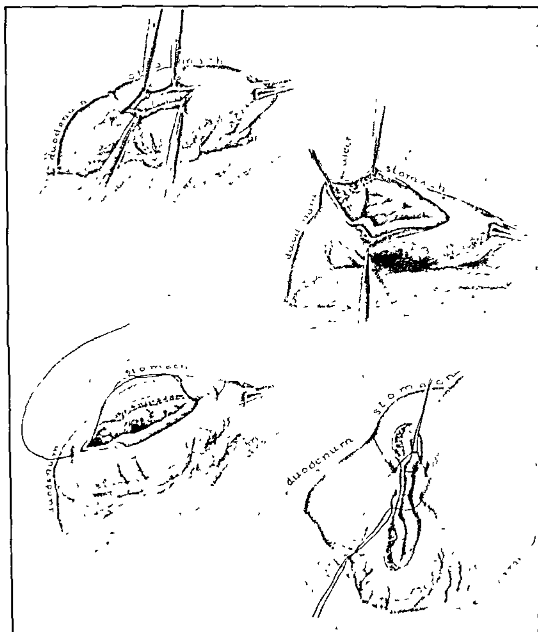



Fig 595 Fig 596.

Fig 593.—The incision through the peritoneal and muscular coats of the stomach has been made and the bleeding vessels are caught. The dotted line surrounds the ulcer which is to be excised.

Fig 594.—The incision has been carried through the gastric mucosa, care being taken not to injure the gastric mucosa The ulcer is shown in the duodenum

Fig 595.—The ulcer has been excised and a tractor suture is being inserted, catching the whole wall of the duodenum but only the muscular and peritoneal coats in the stomach

Fig 596.—Both tractor sutures are being tied.

sutures are gently tied and the ends are left long and held up to prevent regurgitation of the gastric and duodenal contents (Fig. 596).

The hemostatic clamps that have been placed on the bleeding points should remain until the suturing has begun. A row of sutures of 0 chromic catgut starts at the lower extremity of this wound which has been converted by the tractor sutures

Fig 597. Fig. 598.

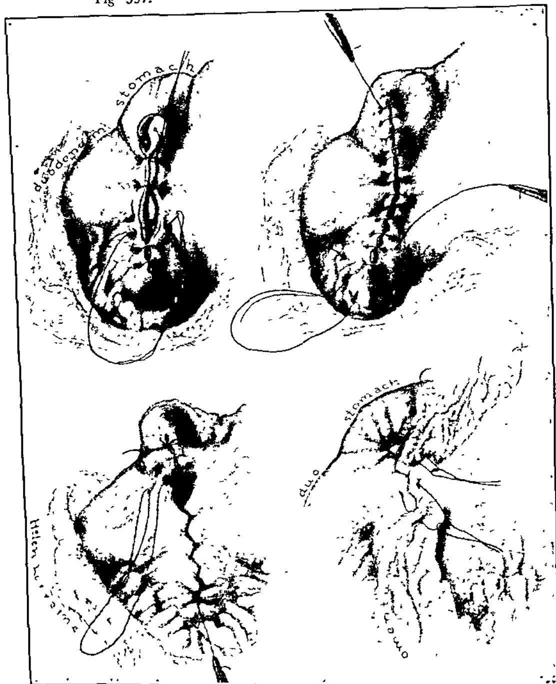



Fig. 599. Fig. 600.

Fig. 597.—The first row of sutures is being placed, taking only the muscular and peritoneal coats on the stomach side but the whole thickness of the duodenal wall.

Fig 598.—The first row of sutures has been completed and the second row of sutures is begun at the lower end of the wound as a purse-string suture. The ends of the tractor sutures should not be cut until the second row of sutures reaches them.

Fig. 599.—The second row of sutures is being terminated as a purse-string suture at the upper end of the wound.

Fig 600.—A few interrupted sutures bring over peritoneum-covered fat.

into a transverse instead of a longitudinal wound. It is inserted with a fine curved needle, and unites the muscular and peritoneal layers of the stomach. It is drawn snugly, for it is a hemostatic as well as an approximating suture. The gastric mucosa is not penetrated by this suture. When the duodenum is reached, the suture catches the whole of the duodenal wall. No attempt is made to invert the edges of the wound, as it would make too great a bulk, and only sufficient tissue is included in the suture to secure a firm hold The clamped vessels are released as the suture proceeds (Fig. 597). As the incision has been made midway between the greater and lesser curvatures, no large vessels are encountered except where the pyloric sphincter is divided. Here, if necessary, an additional backstitch from the suture will add greater security to the tissues and to the hemostasis. If gauze has been inserted into the stomach, it should be removed before the suture is completed. The suture is tied at the upper end of this transverse wound, and the original short end and this end are used as tractor sutures, in addition to the two tractors that were inserted at first. A second row of sutures of fine chromic catgut is placed, beginning at the lower end as a purse-string suture, invaginating the teat of stomach at this point, and is carried upward as a right angle stitch with an occasional backstitch to lock it firmly (Fig. 598). The tractor sutures are cut short as the suture reaches them. A right angle suture is less likely to tear through the wall of the duodenum than an overhand stitch.

The stomach can be readily brought over and as much of it folded over the first line of sutures as desired. When the suture reaches the upper extremity of the wound, it is again converted into a purse-string suture and tied (Fig. 599). In the middle of the suture line one or two interrupted mattress sutures of fine catgut are placed and gastrocolic omentum is brought over the line of sutures and fastened by a few interrupted stitches. A tag of peritoneum-covered fat from above may also be brought over if it can be done without making traction. This serves not only to support the line of sutures but also to protect from adhesions about the gall bladder or the liver. Then, too, the weight of the gastrocolic omentum has a slight downward traction on the line of sutures (Fig 600). In the Heineke-Mikulicz pyloroplasty there is a tendency for the incision as it heals to pull up underneath the liver and make a rather sharp angle This incision, however, because most of it is on the stomach side, should be less likely to be drawn up toward the liver, but even this must be prevented

Adhesions about the pylorus or duodenum are more prone to give symptoms than in portions of the gastrointestinal tract where the range of motion is normally greater. Adhesions about the middle of the transverse colon or about the body of the stomach are frequently symptomless, but adhesions around a viscus whose motion is normally very limited often cause disagreeable and uncomfortable sensations. Adhesions about the heart, for instance, which has a limited but very essential motion, are always a matter of consequence Adhesions about the ileocecal valve or the duodenum will frequently produce clinical disturbances because their very limited range of movement is interfered with, whereas if movement is naturally through a wide range, adjustment to adhesions may be easily made Consequently, it is important in operations about the pylorus and duodenum to make every effort to avoid adhesions, and if adhesions must occur they should be to fatty tissue rather than to relatively solid tissue, such as the undersurface of the liver, or to the gall bladder, which is sensitive to traction from adhesions

It has been well demonstrated that the first part of the duodenum has relatively more resistance against the irritating effects of the gastric juice than the intestine lower down has. Peptic ulcers are more common in the first portion of the duodenum because here is received the first impact of the expelled gastric contents. Consequently, excising a considerable portion of the first part of the duodenum merely because it might be the site of an ulcer later is taking away that portion of bowel peculiarly resistant to the action of the gastric juice. Then, too, excision of the pyloric sphincter, while undoubtedly widening the opening at the time of operation, substitutes for the excised sphincter a wound in the same direction as the sphincter. This, theoretically at least, would be prone to be followed by stenosis, as the scar representing the excised sphincter contracts, whereas in the "physiologic" type of pyloroplasty none of the pyloric sphincter is removed.

In lesions of the stomach itself, no type of pyloroplasty is recommended. A partial gastrectomy is usually more satisfactory in gastric lesions. This is true because excision of a gastric ulcer in the pyloric portion of the stomach may be followed by recurrence of the ulcer and there is a well-known tendency of gastric ulcer to degenerate into cancer.

For the postoperative treatment of pyloroplasty, as for the postoperative treatment of any operation upon the stomach, a "tube" or catheter gastrostomy is done at the time of operation. This is more comfortable and more effective than insertion of a Jutte or Levine tube through the nose. It is aspirated at intervals of one or two hours and kept open. With this tube open the patient can have a liberal amount of water by mouth and small amounts of liquid food. After the second day the tube is clamped for one or more hours and then aspirated in order to ascertain whether the stomach is emptying. This procedure is helpful in relieving gastric tension and the strain on the sutures and is more comfortable to the patient than gastric lavage with a tube through the nose or mouth. In pyloroplasty, even though the opening may be wide, there appears to be more difficulty in emptying the stomach for the first few days than follows gastroenterostomy or the modification of the Billroth I type of gastrectomy which will be described later. In this latter operation the stomach empties more readily and more satisfactorily than after any other operation on the stomach.

The decision between a posterior gastroenterostomy and a pyloroplasty should be carefully made. When there is stenosis, especially marked stenosis; when extensive adhesions exist, or when duodenitis or an infiltrating duodenal ulcer is found, there can be no question that a posterior gastroenterostomy is indicated. When the lesion is limited to a small ulcer in the anterior wall of the duodenum, a pyloroplasty is a satisfactory operation.

All of these facts must be weighed before making a decision. The proper type of operation should be fitted to the pathologic lesion found instead of attempting to make the lesion fit the surgical technic that has previously been selected.

Deaver and Burden described an operation in which the anterior portion of the pyloric sphincter is excised without opening the mucosa. The operation appears to be based upon the observation that spasm of the pyloric sphincter prevents regurgitation of the duodenal contents into the stomach. The ulcer is usually not disturbed in this operation but occasionally it is excised along with half of the sphincter.

This operation seems to offer no advantage over the pyloroplasties discussed, and if the ulcer is not removed the interior of the duodenal and pyloric region cannot be reviewed.

The observation of Sloan that adhesions about the first portion of the jejunum appear to predispose toward duodenal ulcer by causing retention of the duodenal contents longer than normal, is interesting. Certainly such adhesions should be divided when a duodenal ulcer exists, whatever kind of pyloroplasty is done, though the suggestion of Sloan that division of these adhesions is all that is necessary seems somewhat extreme.

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# CHAPTER 52

# THE BILLROTH I TYPE OF PARTIAL GASTRECTOMY

Guy W. Horsley

## HISTORY

Gastrectomy at once suggests the name of Billroth, who did pioneer work in establishing this operation. According to Pierre Rhéaume, the first pylorectomy for cancer was done by Péan on April 8, 1879. Soon after this, Rydigier, of Austria, on November 16, 1880, did a pylorectomy. Billroth, of Vienna, reported his first case in February, 1881, the first successful partial gastrectomy or pylorectomy, and created an era in gastric surgery. He united the stomach to the duodenum, which has been called the Billroth I method.

At that time, the motor function of the stomach was but little understood, and the relative importance of the lesser curvature and the greater curvature was not appreciated. According to priority, the operation should be called Péan-Billroth, but, as Billroth's case is best known, the term "Billroth I" has been applied to the type of gastrectomy in which the stomach is joined to the duodenum. There are many variations of this technic but they are all considered modifications of the Billroth I.

The second type of partial gastrectomy, in which the stomach is united to the jejunum and the duodenum is closed, is known as the "Billroth II." This, according to Rhéaume, was first suggested by von Hacker in 1885 soon after he described his method of posterior gastroenterostomy. He suggested that when the cancer is extensive and there is not enough stomach to join to the duodenum, the lower portion of the stump of the stomach be utilized for anastomosis to the jejunum. Von Eiselsberg, however, in 1888, applied this idea of von Hacker, who was an assistant to Billroth. The operation in which gastroenterostomy was first done and then a portion of the stomach was resected, the duodenum closed, and the stump of the stomach closed was one of the early types of Billroth II.

Polya, in 1911, advocated the method now generally known by his name, in which the stump of the stomach is united to the side of the jejunum. Polya brought the bowel through the transverse mesocolon, but Balfour advocates that the jejunum be carried in front of the transverse colon and that an enteroanastomosis be done.

Finney, of Baltimore, and Haberer, of Innsbruck, independently devised a method of partial gastrectomy in which the stump of the stomach is united to the side of the duodenum, after mobilizing the duodenum and closing its end.

The two types of partial gastrectomy, then, are the Billroth I and the Billroth II. The sleeve resection in which the middle portion of the stomach is resected and

the two ends united, as in intestinal resection, has been almost abandoned. The objections to it, that it may be followed by hourglass constriction and that the resulting function is unsatisfactory, have been discussed.

In operations for gastric ulcer it is often difficult to determine whether the ulcer is malignant. Even examination of the crater of the ulcer might show no evidence of malignancy, while cancerous tissue was on its margin. It seems safer to regard gastric ulcers, if it is necessary to operate upon them, as though they were either actually or potentially cancerous. The operation of partial gastrectomy, if carefully done, involves comparatively little mortality risk and is followed by good function, so practically the same kind of operation should be adopted for peptic gastric ulcer as for a lesion that is definitely malignant

It is thought best to do a total gastrectomy in cases of carcinoma of the stomach if the cancer is above or to the left of the angle of the incision rather than to do a subtotal resection. In all cases of gastric cancer and cases thought to be malignant, removal of the entire omentum seems to be indicated as this removes the lymph nodes along the greater curvature of the stomach and reduces the possibility of recurrence.

## PHYSIOLOGIC BASIS FOR THIS OPERATION

The physiologic reasons for the Billroth I type of operation are rather obvious. Physiologists have shown that the sensitiveness of the intestinal mucosa to hydrochloric acid increases from the duodenum down, and that the duodenum normally has far more resistance to hydrochloric acid than any other portion of the intestinal tract. As has been pointed out elsewhere, along the lesser curvature of the stomach there exist centers for the origin of peristalsis. The greater curvature has no such function. In the distal half of the stomach active peristaltic waves serve not only to macerate food and mix it with gastric juice, but to expel the gastric contents, whereas the cardiac portion of the stomach merely contracts tonically as would a rubber bag, forcing food into the actively peristaltic right half of the stomach. The peristalsis proceeds along the general axis of the lesser curvature, and food is emitted by spurts at intervals as the pyloric sphincter relaxes If, then, the segment of stomach to be removed does not involve all of the actively peristaltic portion, it would be obviously indicated to reestablish the function of the stomach as far as possible and to reconstruct the gastrointestinal tract by uniting the lesser curvature of the stomach to the upper border of the duodenum This can be done in the majority of cases. The cardiac portion of the stomach may be mobilized by reaching under it with the hand and stretching or dividing any retaining bands. Division of the gastric artery also assists in liberating the cardiac portion of the stomach. Mobilization of the duodenum is unnecessary if the operation is to connect the end of the stomach to the end of the duodenum If the Finney-Haberer partial gastrectomy is to be done, the duodenum should be mobilized, as in the Finney pyloroplasty

There are many cases, however, in which the Billroth I type of operation is not applicable. They consist of those in which the duodenum itself is not normal because of active or latent ulcer or because of cicatricial contraction In some cases, too, on account of the fixation of the tissues around the stomach it is impossible to approximate the stump of the stomach to the duodenum, even though the latter be normal. If as much as two-thirds of the stomach is to be removed, the chief indica-

tions for uniting the lesser curvature of the stomach to the upper border of the duodenum do not appear, because in the cardiac third of the stomach there is no active peristalsis but merely the tonic elastic contraction of the wall of the stomach in all directions; and the removal of so much of the stomach probably reduces the acidity of the gastric juice. In such cases union to the bowel may be made along the greater curvature or at any other point along the stump of the stomach without interfering with the physiologic function of the remaining stomach. However, it must be recalled, as previously pointed out, that there is more tendency to peptic ulcer when the jejunum receives the contents of the stomach directly than when the duodenum receives them. Even though the physiologic motor conditions that obtain when the stump of the stomach empties into the jejunum are satisfactory, the possibility of creating a lesion in the jejunum should be considered.

In the original Billroth I operation an end-to-end union was made between the stomach and the duodenum along the upper margin of the stump of the stomach. This was soon abandoned by Billroth, however, because of the difficulties of suturing and the fear of forming a culdesac or diverticulum in the lower pouch of stomach; then suturing the end of the duodenum into the lower portion of the stomach was adopted. In this method, while there was not so much culdesac left and while the excess of tisssue along the lesser curvature was sometimes excised, the suturing was difficult and there was frequently leakage at the so-called "deadly triangle" where the suturing on the stump of the stomach met the suturing by which the duodenum was united to the stomach. On account of this so-called deadly triangle, Billroth abandoned this type of operation for the Billroth II, in which the stomach was united to the jejunum.

The disadvantage of a diverticulum was exaggerated When the physiology of peristalsis was not understood, the importance of preserving the lesser curvature was not appreciated.

Another very marked objection to the original type of Billroth operation, even when the duodenum is united to the lesser curvature, is the difficulty of making a safe union between the thick wall of the stomach and the thin wall of the duodenum without a resulting obstruction.

## A MODIFICATION OF THE BILLROTH I PARTIAL GASTRECTOMY (HORSLEY)

In 1923 J. Shelton Horsley devised a modification of the Billroth I operation which has been most satisfactory. This technic is used when any lesion, either benign or malignant, in the pyloric half of the stomach requires excision.

An abdominal incision just to the right of the midline, extending from the ensiform cartilage to the navel, or below the navel, gives good exposure. If the lesion is toward the cardiac side, the incision should be to the left of the midline or a transverse abdominothoracic incision should be used.

In elderly people, particularly if the adbominal wall is thin, local anesthesia may be employed. The operation can be done under spinal anesthesia, but in the bad-risk type of patients with very high or very low blood pressure in whom general anesthesia is undesirable, a spinal anesthetic is often dangerous. When local anesthesia is to be used, the abdominal wall is infiltrated with the anesthetic solution,

and, after it has been opened, the parietal peritoneum is injected through long needles for several centimeters around the margin of the incision. Then the tissues about the duodenum and the pyloric end of the stomach and around the head of the pancreas are infiltrated. Care must be taken not to inject too deeply. If the solution is placed just under the parietal peritoneum and is injected firmly but slowly, it will infiltrate sufficiently to produce anesthesia. This is done on both sides of the spinal column. The solution contains 0.5 per cent procaine to which 2 or 3 drops of Adrenalin solution are added to each 30 c.c. of procaine solution. The tissues along the root of the transverse mesocolon are infiltrated Injections are also placed high up in the lesser curvature of the stomach beyond the lesion. It is unnecessary to inject the distal side of the lesion, and this might force some of the cancer cells farther into the lymphatics. In younger patients who can obviously stand with safety a general anesthetic, there is no occasion for local anesthesia. In every case, however, no matter what the anesthesia, the stomach should be thoroughly washed out before the operation and the lavage tube should be left in place.

The peritoneal cavity should be explored to determine the type and extent of the lesion and whether there are metastases in the liver or culdesac. As has been pointed out, it cannot always be determined by simple palpation and inspection whether the gastric lesion is benign or malignant. The condition of the liver should be carefully noted. If the liver is markedly contracted or if it is browish yellow in color, the prognosis is very much less favorable than if the liver were approximately normal. Naturally, in elderly people we expect some striae of connective tissue in the liver and some thickening of the gall blader, but advanced liver lesions in cases requiring extensive surgery are particularly serious In a liver of normal size, a yellow brownish color that seems to permeate the whole liver is ominous. A cirrhotic liver, of course, is dangerous, but unless advanced it is less serious than a liver that shows throughout its substance this brownish yellow color, indicating fatty degeneration, even though its size is not diminished.

If, after the examination, a partial gastrectomy seems indicated, the gastrohepatic omentum, which is very thin about its center, is opened. The lymph nodes behind the stomach and beneath the liver should be palpated if they have not already been sufficiently examined. The point of proposed section of the stomach is determined and the gastrohepatic omentum just to the right of this is doubly clamped and divided. There should be ample space between the lesion and the point of section of the stomach, as there is a tendency for cancer in the pylorus to spread along the lesser curvature The gastrohepatic omentum to the pyloric portion of the stomach is also clamped and divided The hand is inserted behind the stomach, the stomach is lifted up, and the gastrocolic omentum opened at the point of proposed section of the stomach on the greater curvature. Then going from left to right, the gastrocolic omentum is doubly clamped and divided in sections. It is quite necessary, however, to lift the stomach well up and to see that the transverse mesocolon is free. In some cases there is a congenital fusion of the gastrocolic omentum and the transverse mesocolon, and injury to the vessels of the transverse mesocolon at about the middle of the greater curvature of the stomach must be carefully avoided Of course, if there are inflammatory adhesions it is natural to look out for the vessels of the transverse mesocolon, but the possibility of congenital fusion should also be borne in mind As the pyloric end of the stomach is approached, particular care is necessary, for here the normal anatomical arrangement of the ves-

sels of the mesocolon makes them very close to the stomach. Then, too, the lymph supply here is abundant and metastases into the lymph nodes are likely to occur at this portion of the greater curvature. However, with a clean field and good exposure, a rather wide berth can be given to the potentially infected tissue in this region without injuring the vessels of the mesocolon.

Whether a diagnosis of cancer is quite obvious or the lesion appears to be a benign peptic ulcer, the operation should be performed as though the growth were cancer. This requires but little more care, the removal of slightly more tissue, and does not add materially to the danger of the operation but it does enhance the chances of permanent cure in cancer. In cases of definite malignancy all of the omentum attached to that portion of the stomach to be removed should also be resected. It is easily dissected away from the transverse colon and is removed along with the resected portion of the stomach.

After the gastrohepatic omentum and the gastrocolic omentum from the point of proposed resection of the stomach to the duodenum have been clamped and divided, the portion of stomach to be removed remains attached only to the duodenum and to the body of the stomach. The clamped sections of gastrohepatic and gastrocolic omentum are transfixed and tied with plain catgut. On the lesser curvature two ligatures of catgut are placed instead of one, because if a ligature should slip at this point it would be more difficult to control the hemorrhage than elsewhere, as the tissues will retract and exposure is difficult. Two ligatures are placed on the duodenal portion of the gastrohepatic omentum for additional security when the two ends of the gastrohepatic omentum are later tied together. Where the stomach is to be divided, two Payr clamps are placed close together (Fig. 601, *A*). Two smaller clamps are fastened on the duodenum just beyond the pylorus. The tissues are well packed off with moist gauze. The stomach between the clamps is divided with a knife; then the stomach is lifted upward and to the right, placing slight tension on the duodenum, and the duodenum is divided in a similar manner (Fig. 601, *B*).

The Payr clamp on the stomach is brought over toward the clamp on the duodenum. If there is decided tension, the stomach is lifted up and any constricting bands or adhesions are loosened, and, if necessary, the gastric artery is divided. This seems simpler than attempting to mobilize the duodenum, and mobilization of the duodenum does not add very much to the relief of tension on the end of the duodenum, though it does, of course, greatly relax the wall of the duodenum if an end-to-side union is contemplated. If the stump of the duodenum on its undersurface shows some attachment to the pancreas, the tissue is gently pushed back until a small but satisfactory cuff of duodenum is available for suturing. Beginning on the undersurface of the lesser curvature of the stomach, a mattress suture of 00 chromic catgut in a fine curved needle is inserted from above downward. The suture is then carried over to the duodenum and is inserted just below the upper border of the posterior surface of the stump of the duodenum, going from below upward. The ends are clamped together, but the suture is not tied (Fig. 601, *C*).

A series of interrupted mattress sutures of this type is placed from above downward. When the lower border of the duodenum is reached, a suture similar to the first is inserted, only it begins at the lower border of the duodenum, comes out on the posterior surface of the stump of the duodenum just above its insertion, and is then carried over the stomach and inserted from above downward. It is not possible to make an end-to-end approximation of the duodenum to the stomach by these

sutures, though later in the operation when the duodenum is flared open, an end-to-end union may be accomplished if the stomach is small. These sutures are tied snugly after all of them are inserted, each knot being tied at least three times. The ends of the lowest and of the uppermost sutures are left long as tractor sutures. The others are cut short.

The packing of moist gauze around the stomach should again be inspected to see that the surrounding tissues are well protected. As has often been pointed out, when the gastric juice has a normal acidity, the gastric contents are practically sterile. In cancer, however, with the absence of acid, the contents may be quite septic if the cancer is a fungating necrotic mass or an open ulcer. It is in this type of case, particularly, that preoperative treatment of gastric lavage and the administration of 0 5 per cent hydrochloric acid is effective in reducing the sepsis.

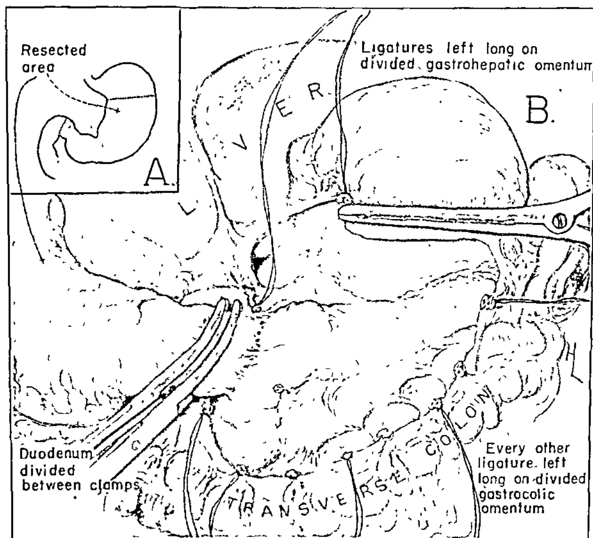



Fig 601 —Partial gastrectomy—Horsley modification of Billroth I

*A*, Amount of stomach to be removed is shown by dotted lines It may not be necessary always to remove this amount.

*B*, The stomach has been doubly clamped, divided between the Payr clamps, and lifted upward and to the right Line of division of duodenum is shown

The Payr clamp on the stump of the stomach is removed, and the crushed margins will at first remain stuck together They are separated, caught with small Ochsner forceps, and the gastric contents are removed by suction If the stomach is

quite large, the lower portion of the stump is not opened but is clamped with forceps. All bleeding points are clamped. The inner layer of sutures is hemostatic, necessarily placed with sufficient pressure to cause the margins of the stomach and duodenum to become necrotic and slough off. The fact that this usually occurs in the mucosa in intestinal suturing, even though there has been no marked constriction by the sutures, was pointed out many years ago by Halstead and Mall.

Occasionally in pyloric obstruction, particularly in elderly people, even after careful gastric lavages with a large stomach tube, there is a retention of food. Undigested corn, beans, and tomato skins eaten days before are sometimes found.

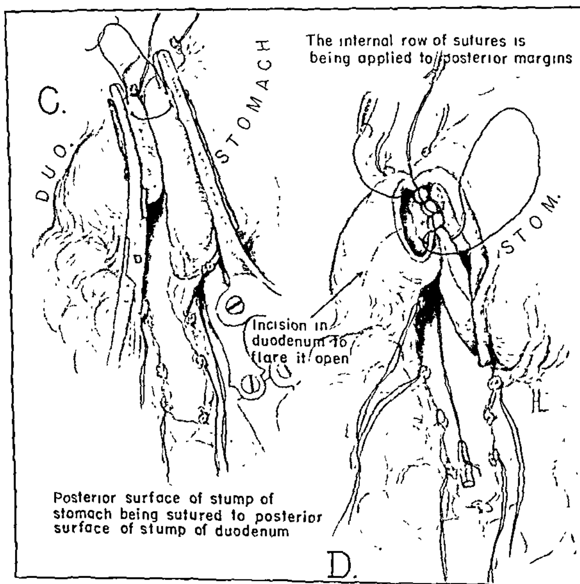



Fig 601 (continued).

*C*, The resected portion has been removed and the duodenum and stump of the stomach have been approximated.

*D*. The two clamps have been removed and the inner row of sutures in the mucosa has been started. The line of incision in the duodenum is shown

These things formed a mushy semisolid mass that cannot be evacuated through the stomach tube but can be best removed by a small ladle which is sterilized with the instruments for a partial gastrectomy when the roentgenologic examination shows a prolonged emptying time and marked retention. If retained undigested material is

present, the stump of the stomach, after being surrounded by moist gauze, is gradually opened and its contents are ladled out. Then salt solution is poured into the stomach and removed by suction. The stomach should not be wiped out with gauze unless the material is extremely tenacious, and then only with gauze wrung out of salt solution. Ordinarily, suction is sufficient.

After the stomach has been prepared, the clamp is removed from the duodenum and the margins of the duodenum are caught with small hemostatic forceps both along the portion that is approximated to the stomach and along the outer wall of the duodenum. The contents of the duodenum are withdrawn by suction, which is used freely during the operation if bile or gastric juice wells into the wound

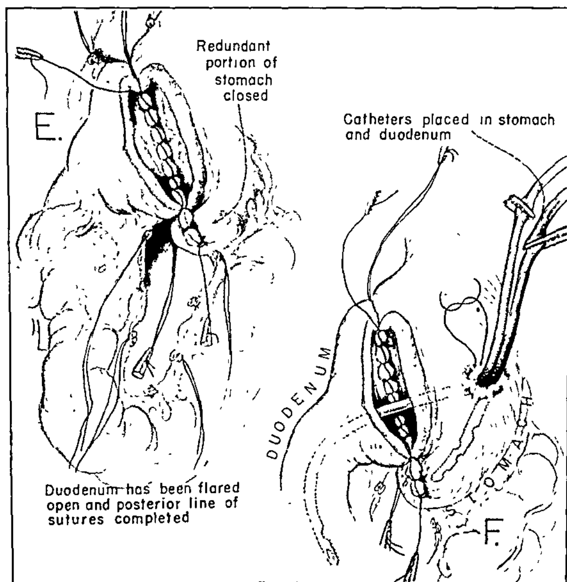



Fig 601 (continued).

*E*, The posterior row of sutures has been completed and the duodenum has been flared open

*F*, The gastrostomy and enterostomy tubes are shown in place and sutured to the gastric wall

The two tractor sutures, consisting of the upper and the lower mattress sutures, are made taut and outline the approximated edges of the stomach and the duodenum. Beginning from within the stomach on the lesser curvature, a suture of 0

chromic catgut is inserted from within outward, coming out on the upper border of the stomach, piercing the duodenum from without inward, and going through the upper border of the duodenum. This suture is tied and the knot rests on the mucosa. The short end of this suture is clamped and the suture is continued downward as a lockstitch, drawn snugly enough to check all bleeding and to approximate firmly the posterior margin of the stump of the stomach to the posterior margin of the stump of the duodenum. This suture line is then reinforced with two or three interrupted sutures of 00 chromic catgut. (Fig. 601, *D*.) When the lower border of the duodenum is reached, a finger is inserted into the duodenum in order to ascertain accurately its axis. With scissors an incision is made in the anterior wall of the duodenum for about 2.5 to 3.75 cm. This should be a little below the center of its anterior surface.

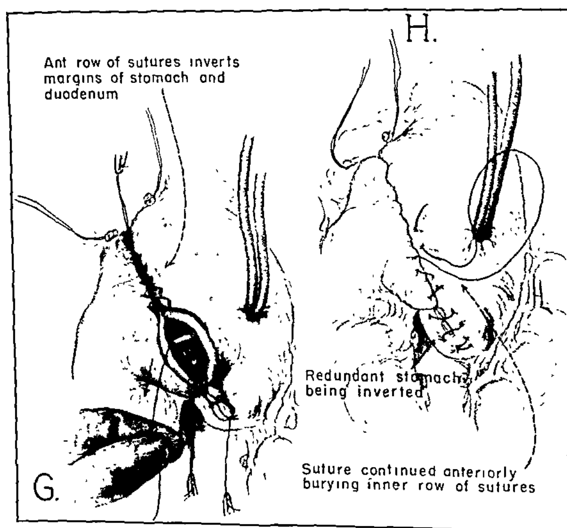



Fig. 601 (continued).

*G*, The first row of anterior sutures is being placed. The suture is tightened as it emerges from the gastric mucosa.

*H*, The small pouch of stomach is inverted and the second row of anterior sutures is being placed.

If this incision in the duodenum is made too soon, it interferes to some extent with the accurate approximation of its upper border and the lesser curvature of the stomach. It is important for physiologic reasons that the upper border of the stomach be united accurately to the upper border of the duodenum. When these

tissues have been firmly fixed, not only by the first row of mattress sutures, but by a continuous lockstitch, the lower border can then be flared open without any danger of displacing the approximation along the upper and physiologically more important portions If the stomach is small, the lockstitch may be continued so that the greater curvature of the stomach is united to the lower border, or rather to the lower flared-out portion, of the duodenum, making an end-to-end union. A small stomach is usually found when the gastric lesion is not obstructive. If an end-to-end

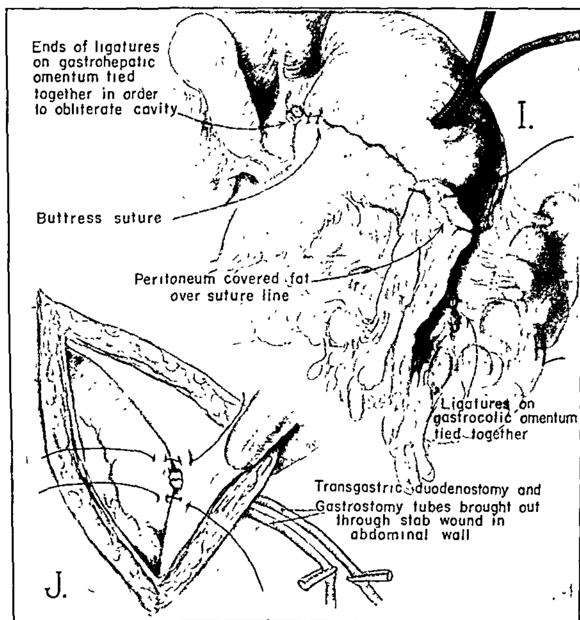



Fig. 601 (continued).

*I*. The anastomosis has been completed and the reinforcing sutures are in place The opening in the gastrocolic omentum has been closed

*J*. The gastrostomy and enterostomy tubes are brought out of a stab wound and the stomach is attached to the abdominal wall

union is impossible, the suture, after uniting the additional flared-open portion of duodenum to the stomach, is continued over this redundant lower part of the gastric stump, still applying it snugly, and the knot is tied at the greater curvature (Fig. 601, *E*). A second internal suture is begun at the lesser curvature, in a similar

manner to the preceding suture, going from within outward in the stomach and from without inward in the duodenum. After tying it, the end of this suture is also tied several times to the end of the preceding suture in order to afford still greater security in the approximation of the tissues along the lesser curvature (Fig. 601, *F*). At this point the gastrostomy and transgastric duodenostomy tubes are put in place as described in Chapter 50, page 772. The suture is then carried anteriorly, being applied in the same manner as it was originally introduced, that is, inserted in the stomach from within outward and in the duodenum from without inward. Where there are bleeding vessels, an additional stitch is made. If this suture is drawn snugly only after it emerges from the duodenal mucosa, and while a finger of the left hand presses on the tissues just above it, the margins of the stomach and duodenum are inverted, and much the same effect is produced as with the suture applied to the posterior margins of the stomach and duodenum (Fig. 601, *G*). In other words, this suture not only infolds the edges of the stomach and duodenum but affords a much safer hemostatic effect than could be obtained if it were applied as a continuous mattress suture from without. As in a gastroenterostomy, a continuous mattress suture is not necessarily hemostatic, for the tissue on one side opposite the loop of the suture on the other side has but little compression to prevent bleeding. This anterior continuous suture is thus practically applied from within, and sometimes two or three stitches are taken before the thread is drawn taut When the lower border of the duodenum is reached, the suture is tied.

If the stomach and duodenum can be united end to end, it is advisable to carry the posterior suture up a few stitches above the greater curvature. Then the anterior suture can be tied snugly in the lower anterior wall and is more readily buried than if it were tied at the greater curvature. If, however, there is a redundant lower end of the stomach, the suture may be either terminated at the lower border of the duodenum or carried over the redundant portion of the gastric stump and tied at the lower border of the stomach This redundant portion is infolded with a suture of 00 chromic catgut which begins on the duodenum, is carried well around the greater curvature, and returns anteriorly (Fig. 601, *H*). As it is tightened, the redundant portion of the stump of the stomach is inverted. This suture is continued anteriorly as a continuous right angle stitch with an occasional backstitch, burying the inner row of sutures. It is tied at the lesser curvature. The ends of the ligature on the lesser curvature of the stomach are tied to the ends of the ligature placed near the upper border of the duodenum. For additional security a mattress suture of 00 chromic catgut is taken between the lesser curvature and the duodenum. This suture should go well onto the stomach and is tied without too much tension. Excessive tension in this region should be avoided. Another suture is placed between the greater curvature and the duodenum for additional security, and, after being tied, some adjacent peritoneum-covered fat is caught with this suture, which is again tied. A few interrupted mattress sutures of 00 chromic catgut may be placed anteriorly and, if there is easily accessible peritoneum-covered fat, this also is brought over and caught in these sutures (Fig. 601, *I*). The gap in the gastrocolic omentum is obliterated by suturing the edges together with catgut.

This operation—a modification of the Billroth I—has been used with much satisfaction. It provides ample exit for the gastric contents and usually there is smoother convalescence so far as the emptying of the stomach is concerned than after the lesser procedures of pyloroplasty or gastroenterostomy. During all opera-

tions on the stomach a stab wound gastrostomy and enterostomy as described in Chapter 50 are done. It is far better than inserting a nasal gastric tube, and there have been no complications incident to the use of these tubes.

It is frequently necessary to vary this technic to suit the existing conditions. If there are marked adhesions about the pyloric end of the stomach, it may be better to divide the body of the stomach first, turning up the distal end so there will be good exposure of the adhesions around the pylorus. If it has been determined that the growth is cancerous and adherent to the pancreas, a small section of the adherent pancreas can be removed with the dissection. This is usually followed by considerable bleeding, which with the friable pancreatic vessels is sometimes difficult to control. Mosquito forceps are serviceable in obtaining hemostasis in this region. The bleeding area is sutured with fine plain catgut. If adhesions are extensive about the lesser curvature, the gastrocolic omentum should be opened first, the vessels along the upper border of the duodenum and pylorus clamped and cut, and the duodenum severed. The stomach is then lifted up and the body of the stomach divided between Payr clamps, leaving the portion of the stomach to be resected attached solely to the adherent tissue along the lesser curvature. This gives better exposure in a difficult situation. The gastric artery is identified, clamped, and divided, and the other tissues and adhesions are then severed.

If there is an ulcer in the posterior wall of the stomach that has perforated into the body of the pancreas, the same procedure which has just been described may be carried out. A thin layer of the pancreas that is adherent to the ulcer is shaved off during the dissection When a peptic ulcer of the pyloric portion of the stomach or of the duodenum has perforated into the pancreas, the gastrohepatic and the gastrocolic omentums are severed, the stomach is doubly clamped about its middle, divided, and the distal portion is lifted up. The adherent pancreas is pared away and this exposes the duodenum. If the ulcer is perforating from the duodenum, the dissection is made from the head of the pancreas, care being taken not to remove more pancreas than is necessary to avoid opening the ulcer. With the ulcer in the head of the pancreas, but little stump of the duodenum is left and it may be impossible to clamp the duodenum.

Usually in operations upon the stomach for peptic ulcer the gastric contents are highly acid, and this being antiseptic there is less danger of infection following operation than would occur in operations for cancer in which the gastric juice may be low in acid values. Packing around the duodenum with gauze and using suction make the likelihood of infection quite small.

A peptic ulcer that has perforated into the pancreas always causes some local pancreatitis, which occasionally extends. The most satisfactory treatment for such a condition is a partial gastrectomy with excision of the ulcer and a layer of the adherent pancreas.

The advantages of this technic are that the ulcer is removed along with the superficially infected part of the pancreas, and at the same time the stomach is permitted to empty physiologically into the duodenum, which is more resistant to the gastric juice than the jejunum. A primary gastroenterostomy in these cases leaves the lesion in situ, though there may be circumstances in which a gastroenterostomy is indicated, as when the reaction around the ulcer is very extensive.

As a matter of fact, in this type of partial gastrectomy for peptic ulcer we now rarely clamp the duodenum, but divide the stomach first between clamps and then

sever the duodenum, catching the margins of the duodenum as it is divided and keeping the field clean with suction.

A stab wound gastrostomy and enterostomy have been referred to in Chapter 50. We use this now in all types of gastric surgery, instead of placing a tube through the nose or mouth into the stomach. Before closure of the wound in the stomach, whether it is a gastroenterostomy, pyloroplasty, or gastrectomy, a sharp-pointed hemostatic forceps is thrust directly through the stomach from within and grasps the catheters, one of which is brought into the stomach about 7.5 cm., and the other passed down into the small bowel several centimeters below the line of anastomosis. The two catheters are then fixed to the peritoneal coat of the stomach with a fine chromic catgut suture. A purse-string suture is placed around this, and a stab wound is made to the left of the abdominal incision and the end of the catheter is brought through the stab wound. The stomach is fastened to the parietal peritoneum (Fig. 601, *J*).

As has been previously stated, a mass of necrotic cancerous tissue in the pyloric portion of the stomach which harbors saprophytic and pyogenic bacteria may often be resected with great comfort to the patient, even when there are small irremovable metastases in the liver or elsewhere. Undoubtedly a partial gastrectomy is preferable to a gastroenterostomy which leaves behind septic and necrotic tissue.

## THE FINNEY-HABERER MODIFICATION OF THE BILLROTH I PARTIAL GASTRECTOMY

There are, of course, many modifications of the Billroth I method of partial gastrectomy. The above technic has been described fully because it is the operation used in most of our cases and has been found to be very satisfactory. There are other excellent technics. The objections to operations in which most of the lesser curvature is excised and a tunnel is made along the greater curvature have been discussed in the section on physiology of the stomach, and elsewhere. When the duodenum can be well mobilized, the Finney-Haberer operation may be employed. This requires thorough mobilization of the duodenum. The pyloric portion of the stomach is resected, as already described. The cardiac end of the stomach is mobilized, when necessary, by dividing adherent bands and the gastric artery. It is important that there be no tension upon the line of sutures. The end of the duodenum is closed by first placing a basting stitch of silk beginning and ending at a right angle to the clamp and well below the level of the clamp so that the ends of the bowel may be easily tucked in. This suture is continued across the clamp (Fig. 602) and ends as it began in a bite at a right angle to the clamp and at some distance from it. The two ends of the suture are held taut parallel with the clamp, which is gradually released and withdrawn. This procedure usually folds in the bowel satisfactorily. One end of the suture is then doubled back as a second row of sutures and is tied to the other end. Or the bowel may be puckered up on this thread and the two ends tied together somewhat as a purse-string suture. Which of these procedures is better depends upon the local conditions. If the duodenal wall is thin, puckering up the bowel and tying the two ends of the basting stitch together is probably better. If, however, there is a moderate amount of fat and the tissues are thick, it would be preferable to double back the suture. Under either condition, two or more rows of sutures or of purse-string sutures should be

applied (Fig. 603), the outer sutures preferably of fine chromic catgut, with the ends passed through adjacent peritoneum-covered fat and tied, so affording additional protection to the infolded stump of the duodenum. The tissues about the pancreas may be utilized to cover the duodenal stump, but the pancreas itself should not be included in the suture. Though the suturing may appear to be secure, there is a *great tendency for it to loosen, with a resulting duodenal fistula, particularly in* the Billroth II type of operation where retrograde peristalsis or tension from the duodenal contents strains the sutures.

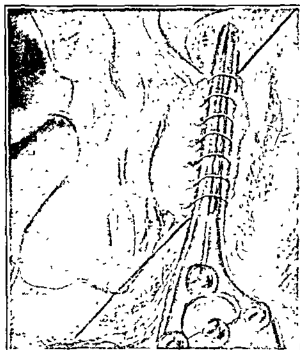


Fig. 602—The duodenal stump is sutured over with a right angle continuous suture which is drawn tight as the clamp is removed

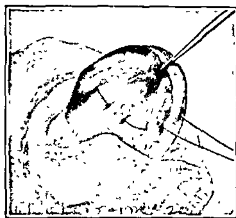


Fig. 603—Purse-string sutures are added still further to invaginate the duodenal stump for a Finney-Haberer partial gastrectomy

The stump of the stomach is brought over and its posterior surface fastened to the side of the mobilized duodenum with continuous or interrupted sutures of chromic catgut. An incision is then made in the duodenum, the duodenal contents are drawn off by suction, the clamp on the stump of the stomach is removed, and the gastric contents are evacuated by suction. Beginning above, the posterior mar-

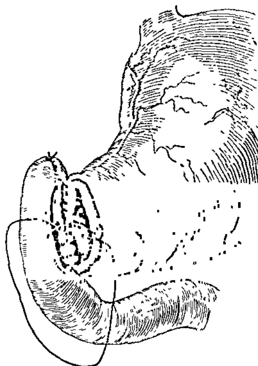


Fig 604.—The Finney-Haberer partial gastrectomy The end of the duodenum has been closed with purse-string sutures The duodenum has been *mobilized, and the posterior wall* of the stomach near the end of its stump has been sutured to the side of the duodenum. An incision is then made in the duodenum. The inner row of sutures is being applied Then the operation is completed as in gastroenterostomy.

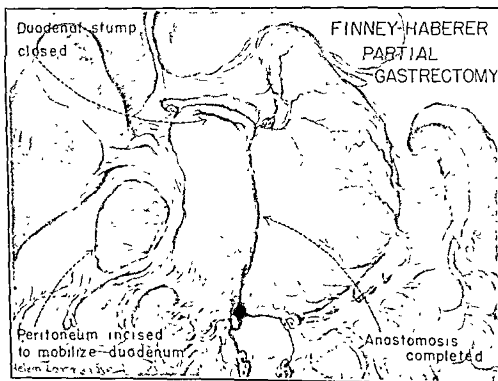



Fig. 605.—Finney-Haberer partial gastrectomy The operation has been completed Note how the duodenum has been mobilized.

gin of the stump of the stomach is united to the posterior margin of the wound in the duodenum with a continuous lockstitch of 0 chromic catgut (Fig. 604). This is continued anteriorly, in the manner described for the inner row of sutures in posterior gastroenterostomy, and tied to its original end. Finney does not insist upon the use of interrupted mattress sutures in this operation, and leaves to the operator his choice as to the suturing to be employed. The principle is that of uniting the end of the stomach to the side of the duodenum. After the inner row of sutures has been completed, anterior sutures are applied Too much of the stump of the stomach must not be turned in at the lower end of the duodenal incision. The desire to make this region safe by additional suturing may result in obstruction at this point. (Fig. 605.)

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# CHAPTER 53

# THE BILLROTH II TYPE OF PARTIAL GASTRECTOMY; TOTAL GASTRECTOMY; THE DEVINE OPERATION

Guy W. Horsley

The Billroth II type of partial gastrectomy has been described while discussing the history of gastric surgery. It is a partial gastrectomy in which the end of the duodenum is closed and the stomach is united to the jejunum In the original operation the stump of the stomach was closed and a gastroenterostomy was done. Sometimes the gastroenterostomy was done first, and then the distal portion of the stomach was resected.

There are numerous modifications of this type of operation. The procedure that seems most logical is the Hofmeister or Finsterer modification of the Billroth II. Closing the stump of the stomach and then doing a gastroenterostomy not only requires much of the stomach in order to make a satisfactory anastomosis but also involves a considerable amount of additional suturing.

The Reichel-Polya operation in which the whole end of the stomach is anastomosed to the side of the jejunum has been quite popular. This may be done either through a rent in the transverse mesocolon, making a retrocolic anastomosis, or by bringing the jejunum over the colon as practiced by Balfour. In the latter case the loop of jejunum should be ample, or else changes in the circulation and swelling may cause obstruction. When the loop is long, an enteroanastomosis may be necessary to facilitate the emptying of the afferent loop. If the posterior Polya operation can be done, it seems preferable; but when the stump of the stomach is small and difficult of access through the transverse mesocolon, the anterior operation is indicated.

## THE POLYA MODIFICATION OF THE BILLROTH II PARTIAL GASTRECTOMY

If the posterior Polya operation is done, the stomach is resected as has been already described, Payr clamps having been placed on the body of the stomach and small clamps on the duodenum. The stump of the duodenum is closed. It is well to note that in this type of operation, the back-pressure in the duodenum may be marked. In the Billroth II operation and in the total gastrectomy great care should be exercised when closing the duodenum. Leakage of the duodenal stump has been a serious complication following these procedures, and in some clinics drainage of this region has been advocated as a routine procedure. While the clamp is still on the duodenal stump, a running over-and-over suture is placed, the clamp is re-

moved, and the suture drawn taut. This suture may be either silk or chromic catgut. The *first row of sutures is now inverted with interrupted mattress sutures* of chromic catgut. This will usually suffice for a permanent closure, but it is advisable to place two or three additional interrupted sutures in the anterior border of the duodenum, catching the peritoneum just over the pancreas so that, when these sutures are tied, the line of the closure is buttressed against the head of the pancreas (Figs. 606 and 612).

A large opening is made in the transverse mesocolon at such a point that at least a portion of the stump of the stomach can be delivered through it. A loop of jejunum is selected at a greater distance from the origin of the jejunum than in a posterior gastroenterostomy. This loop is brought through the mesocolon and sutured to the posterior surface of the stump of the stomach, which is still closed with a Payr clamp (Fig. 606). The suturing is applied as in the first stage of posterior gastroenterostomy, with a continuous or interrupted mattress suture of fine chromic catgut. The loop is so applied that the afferent portion is at the lesser curvature. In this way the afferent loop floods all of the anastomosis with its alkaline contents, which should tend to prevent the occurrence of peptic ulcer—an infrequent but much dreaded sequela.

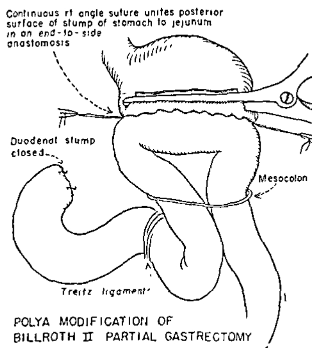



Fig 606 —Polya modification of Billroth II partial gastrectomy Note type of duodenal closure and length of jejunal loop

After this row of sutures has been applied, the loop of jejunum may be clamped with a soft-bladed clamp or, better still, it may be isolated with small rubber bands as has been described, which avoids the trauma to the jejunal mucosa opposite the stoma that a clamp might make. However, clamps are not necessary here any more than in a gastroenterostomy, and most of the anastomoses are done without clamps (Fig 607)

After packing around the tissues with moist gauze, make an incision in the jejunum not quite as long as the stump of the stomach The bleeding points are

Fig. 607. Fig. 608.

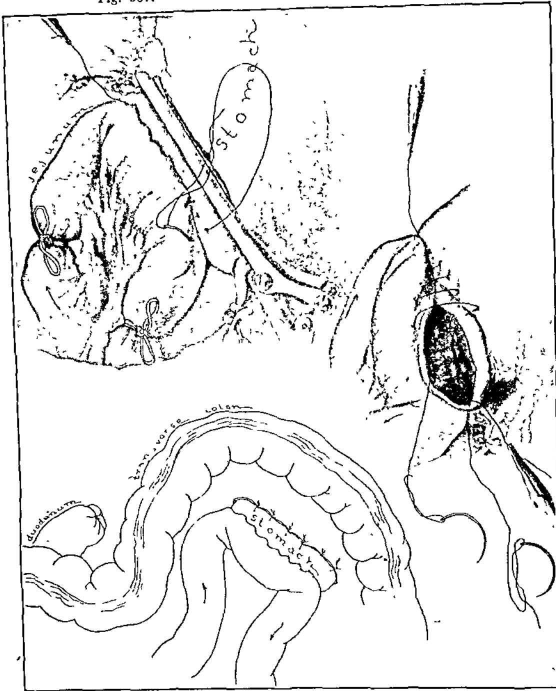



Fig 609

Fig 607 —The side of the loop of jejunum that has been isolated by small rubber bands is sutured to the posterior surface of the stump of the stomach with a continuous right angle suture of fine chromic catgut, using an occasional backstitch

Fig 608 —The Payr clamp on the stump of the stomach has been removed and the jejunum incised. The posterior margin of the wound in the stomach has been sutured to the posterior margin of the wound in the jejunum as in gastroenterostomy. The anterior suture of 0 chromic catgut is being applied in the same manner as described in the modification of the Billroth I, so that the margins of the wound are inverted as the suture is drawn taut when it emerges from the mucosa of the jejunum

Fig. 609 —The suturing of the jejunum to the stump of the stomach has been completed and the anastomosis is drawn down through the opening in the transverse mesocolon It is not always possible, however, to draw it down as fully as shown in the illustration, but at least a portion of it should be brought down.

clamped but not tied. The Payr clamp is removed from the stomach and, beginning at the lesser curvature, a continuous suture of 0 chromic catgut is applied from within outward in the stomach and from without inward in the jejunum, as has been described in the modification of the Billroth I operation. This is carried downward as a continuous lockstitch, uniting the posterior margins of the gastric and jejunal wounds. When the greater curvature is reached, the suture is carried anteriorly for a few stitches. Another row of sutures unites the anterior margin of the stump of the stomach to the anterior margin of the incision in the jejunum. This suture is applied as has been described in the modification of the Billroth I, and begins from within the stomach at the lesser curvature, going through the jejunum from without inward. It is drawn snugly as it emerges from the jejunal mucosa while pressure is made upon the suture line just above it, thus inverting the edges of the wound (Fig. 608). The end of this suture is tied to the end of the preceding posterior inner line of sutures that was carried anteriorly for a few stitches. The first line of sutures of fine chromic catgut is again taken up and carried anteriorly, burying the inner row of sutures. This is reinforced by a few mattress sutures of fine chromic catgut at the upper and lower gastric borders.

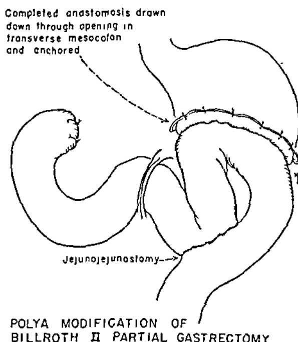



Fig 610—Polya modification of Billroth II partial gastrectomy is completed Occasionally an enteroenterostomy is necessary, as shown here

An effort is then made to draw down as much stomach through the rent in the mesocolon as can be done without too much tension It may be that all of the stoma cannot be brought down, but at least the lower portion can be delivered and a few sutures are placed between the margin of the wound in the mesocolon and the stomach, as far above the stoma as possible (Fig 609) If all of the gastric stump cannot be delivered, some of these sutures are placed in the loop of jejunum. Usually there is no necessity for an enteroenterostomy in this operation, but if there is evidence of kinking at the union of the loop of jejunum to the upper border of the stomach, it would be safer to do an enteroenterostomy between the two loops of jejunum just below the transverse mesocolon (Fig 610) This, however, should

be made small in order not to divert too much of the alkaline duodenal contents from the site of the anastomosis of the stomach and jejunum.

If the operation is done antecolic, the technic so far as the union of the stomach and jejunum is concerned is identical with the posterior operation, but a much longer loop of jejunum must be taken to avoid the possibility of obstruction or kinking from the swelling that follows, and an enteroenterostomy may be necessary between the limbs of the loop of jejunum just below the transverse colon.

Here, as in the other types of gastric resection, a gastrostomy for drainage and decompression of the remaining portion of the stomach and an enterostomy for early feeding are advised. These two tubes may be placed as described in the section on Billroth I type of resection or as advocated by Allen and Donaldson and described in Chapter 50. If, however, neither of these procedures seems advisable in any one case, then a nasal gastric tube placed in the stomach before operation may be left in place. If it has a single lumen, additional holes may be made in it and the tube pulled down several centimeters below the anastomosis. In this way there will be openings in the portion of the tube in the stomach and that in the small bowel. The tube will help drain gastric contents into the bowel, and still the contents of both may be aspirated and distention prevented. A double lumen tube, of which one end remains in the stomach and one end passes down into the bowel, may be used Because of discomfort to the patient and tendency to pharyngeal irritation, nasal tubes are not recommended, unless the gastrostomy and enterostomy tubes are contraindicated.

## THE HOFMEISTER MODIFICATION OF THE BILLROTH II PARTIAL GASTRECTOMY

The Hofmeister type of Billroth II partial gastrectomy seems preferable to the Polya. When so much of the stomach has been resected that a Billroth I is impossible, it is probable that practically all of the stomach in which there is peristalsis has been removed. In the remaining portion there is tonic contraction. In such a case there is no physiologic indication for making the stoma at the lesser curvature of the stomach. The stoma can be made with at least equal efficiency at the greater curvature, because when the cardiac remnant of the stomach tonically contracts on all sides, gravity may aid in emptying, whereas with the action of peristaltic waves arising along the lesser curvature gravity helps but little.

According to the technic of Hofmeister, the stomach is resected and, after removal of the Payr clamp, the upper part of the stump of the stomach is whipped over with a through-and-through suture of chromic catgut (Fig. 611). No effort is made with these sutures to invert the margins of the wound, because to do so would be to open unnecessarily this portion of the stump of the stomach. This suture is buried by one or two rows of catgut sutures applied as a right angle continuous stitch and then reinforced by a few interrupted sutures of fine chromic catgut If the stomach has been greatly dilated and the stump is wide, a large proportion of the stump is closed. Under any condition it is best to leave an opening about 5 cm. long in the lower portion of the stump.

A clamp remains on the lower portion of the gastric stump until the first row of sutures to the jejunum is applied. The loop of jejunum to be anastomosed is brought through a rent in the mesocolon. It should be nearer the origin of the

jejunum than the loop for a Polya anastomosis because less of it is required for a union to the stomach. However, the distance between the origin of the jejunum and the upper portion of the loop to be anastomosed should be sufficient to insure that no undue tension will occur if the stump of the stomach retracts somewhat. After bringing it through the rent in the mesocolon, it is fastened to the posterior surface of the lower portion of the gastric stump by two tractor sutures of catgut, as described in posterior gastroenterostomy. These sutures may be wrapped around a frame, as in gastroenterostomy, if the tissues involved can be raised out of the abdomen without too much traction.

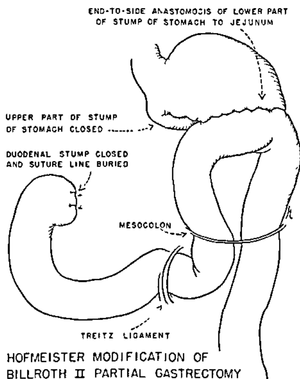



Fig 611.—Hofmeister modification of Billroth II partial gastrectomy. A portion of the stomach along the lesser curvature is closed.

The jejunum is sutured to the lower portion of the posterior surface of the stump of the stomach with a continuous suture of 00 chromic catgut. The loop of jejunum may be clamped with a soft-bladed clamp or two small rubber bands may be applied, as has already been described, one above and one below the proposed site of the anastomosis. However, a short loop may be kept empty by suction as in gastroenterostomy, without the need of any temporary occlusion. An incision about 6 cm long is made in the jejunum. The lower portion of the stump of the stomach is opened. Beginning at the upper end of this opening, the posterior edge of the stump of the stomach is sutured to the posterior margin of the wound in the jejunum with a continuous lockstitch of 0 chromic catgut When the lower border is reached, the suture is continued anteriorly and applied as a continuous suture with the effect of being applied from within, as has already been described, drawing the suture taut as it emerges from the mucosa of the jejunum. It is tied to its original knot at the upper portion of the wound.

The first row of sutures is again taken up and carried anteriorly as a continuous right angle stitch with an occasional backstitch and is tied to its original knot

The upper portion of the loop of bowel is brought over the lower part of the inverted upper portion of the stump of the stomach and fastened with a few interrupted sutures of fine chromic catgut. This is done to reinforce the upper end of the stoma. A few additional interrupted sutures are placed where indicated, particularly at the lower end of the stoma, but the possibility of obstruction from turning in too much of the protruding snout from the stomach must be considered. Usually in this Hofmeister technic the site of the anastomosis can be brought down through the rent in the mesocolon and the stomach fastened to the mesocolon by a few interrupted sutures of catgut as in posterior gastroenterostomy In fact, after closing the upper portion of the gastric stump the technic resembles a posterior gastroenterostomy.

In this type of resection it may be advisable to use a de Petz clamp and divide the stomach between the metal clips. The upper edge is then readily infolded and the lower edge excised along the site of the anastomosis and joined to the jejunum as described above.

This operation allows a more extensive resection of the stomach than would be possible if the original Billroth II operation of closing all of the stump of the stomach and doing a gastroenterostomy were performed. It requires a shorter loop of jejunum than the typical Polya operation with less opportunity for kinking or obstruction and avoids an unnecessarily large opening into the jejunum, while providing an ample exit for gastric contents.

One objection to the Hofmeister operation is that if the incision of the gastrectomy is made in such a manner as to leave a marked redundancy along the greater curvature, infolding of the upper portion of the stump may convert the lower portion into a kind of snout and produce occlusion. To avoid this, the incision in the stomach should be made with a distinct slant from the lesser curvature downward and to the left. Even then, if there appears to be too much redundancy, the lower portion of the stump should be cut away.

## THE ROUX TECHNIC FOR PARTIAL GASTRECTOMY

Partial gastrectomy after the *en Y* or Roux method has occasionally been performed. In this operation the jejunum is severed about 15 cm. below its origin, the distal end closed and its side applied to the stomach as in the Hofmeister or Polya technic. The proximal end of the jejunum is sutured end-to-side to the jejunum farther down.

This procedure has little to recommend it. It violates one of the principles of gastric surgery, for it promotes the sequela of peptic ulcer by draining away from the gastrointestinal anastomosis all of the alkaline duodenal contents except such as may regurgitate by reversed peristalsis. Mann and his colleagues have shown clearly that in dogs surgical duodenal drainage, which is, essentially, this type of operation, is almost invariably followed by jejunal ulcer. Though an enteroanastomosis between long loops of jejunum sidetracks some of this alkaline material, unless this opening is very large the main current of intestinal contents is doubtless carried along the regular channel of the bowel, the enteroanastomosis acting more as a safety valve to prevent excessive distention. In the *en Y* operation, however, all of the duodenal contents are deliberately shunted away from the stoma.

## TOTAL GASTRECTOMY

Except in some unusual case the gravity of the operation justifies total gastrectomy only in malignancy. It must be determined that the lesion is confined to the stomach or, in addition to the gastric lesion, to easily removable metastases as in adjacent lymph nodes, and that all of the stomach must be removed to eradicate the disease. In the marked tendency to recurrence of peptic ulcer occasionally seen even after medical treatment and numerous operations, including subtotal gastrectomy with excision of the vagus nerves and jejunostomy, total gastrectomy might be considered. In linitis plastica, when the gastric wall is greatly thickened and the stomach is contracted and converted into a firm ball, the difficulties of the operation are much diminished.




Fig 612 —Total gastrectomy The duodenum has been divided and is being closed. Note that the suture in anterior part of duodenum catches the peritoneum over the pancreas and turns the suture line backward against the pancreas The stomach is lifted upward and the esophagus is freed as it passes through the diaphragm

The improvements in the technic of total gastrectomy have lessened some of the previous objections to this operation. Two of these technical improvements are particularly valuable. One is the prevention of reflux material going from the

stomach into the esophagus; the second is the suturing of the jejunum to the posterior wall of the esophagus before the stomach is removed.

In this operation all of the omentum is removed with the stomach, and the attachments to the stomach along the greater and lesser curvatures are severed as in a partial gastrectomy. Before the operation is started, a Levine tube is inserted through the nose into the stomach, and continuous low-pressure suction is applied to this tube. In this way regurgitation into the esophagus that might be caused by lifting up the stomach is avoided. This regurgitated fluid may flow back again into the abdomen when the esophagus is divided and contaminate the peritoneal cavity. The attachments to the spleen are delicate and must be carefully clamped and divided. Thorough hemostasis is made. The clamped tissue is controlled by transfixing and tying it with plain catgut. The duodenum is doubly clamped and divided. The stomach is lifted up, using suction on the Levine tube. The stomach thus forms a kind of handle for the esophagus. (Fig. 612.)

The loop of jejunum for the anastomosis is chosen with special reference to having the oral part of the loop sufficiently long to reach the diaphragm not only without tension but also with a redundant portion of it hanging well below the transverse colon if the anastomosis is to be antecolic. A shorter loop is required if the loop of jejunum is brought up retrocolic. An interrupted suture of silk is passed from the upper surface of the side of the loop of the jejunum, about halfway between the mesenteric and the convex border, to the left portion of the posterior surface of the esophagus. The ends are left long. A similar suture is inserted between the right border of the esophagus and the jejunum, leaving space of about 4 to 4.5 cm. between the two sutures. (Fig. 613 ) While these tractor sutures are held taut, additional sutures of silk unite the jejunum to the posterior wall of the esophagus, and one or two sutures at each end of this suture line attach the jejunum to the diaphragm and take some of the downward pull off of the anastomosis. A transverse incision is made in the posterior wall of the esophagus beginning on the right side, and an incision is made in the jejunum about 0 5 cm. from the suture line. The esophagus and jejunum should be thoroughly surrounded with moist gauze before the first sutures are placed, and as soon as the opening into the esophagus and the jejunum is made, suction is applied. Beginning on the right side interrupted silk sutures in a small curved needle unite the posterior margin of the incision in the jejunum to the posterior margin of the incision in the esophagus. The suturing is then continued until the left border of the esophagus and the left extremity of the incision in the jejunum have been reached. The incision in the esophagus is carried anteriorly, catching the margin of the esophagus as it is cut in order to prevent retraction. The suture is continued around anteriorly, uniting the anterior margin of the wound in the esophagus to the anterior margin of the wound in the jejunum. As far as possible it is well to apply this suture from within so that the knot will be tied on the mucosal side.

A second row of sutures is now placed anteriorly, burying the inner row. Over this is placed a series of interrupted mattress sutures of silk, to give further strength to the union, and particularly reinforcing the two lateral borders. The jejunum is next sutured to the anterior edge of the hiatus in the diaphragm to prevent tension

on the anastomosis. If any available peritoneum-covered fat is found, it should be brought over and caught with the long ends of these mattress sutures.

Occasionally, instead of closing the stump of the duodenum the right half of the jejunal loop is brought over and sutured to the stump of the duodenum end to side. By this procedure several things are accomplished: First, by fixing the jejunum to the duodenum a volvulus of the jejunal loop can be avoided. Second, the duodenal contents can readily drain into this loop, if there happens to be some blockage lower down. Third, a duodenal fistula is less liable to occur with the easy emptying of the duodenum.

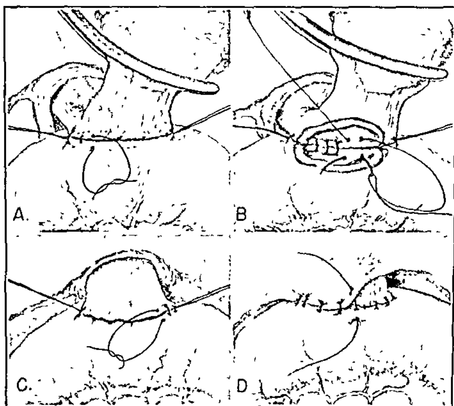



Fig. 613 —Total gastrectomy *A*, The jejunum is first sutured to the posterior edge of the esophagus Dotted lines indicate incision *B*, Incisions have been made in both jejunum and esophagus, and the mucosa is being sutured together *C*, The first anterior suture line has been completed and is being reinforced by a second row *D*, The anterior edge of the opening in the diaphragm is sutured to the jejunum to give better support to the anastomosis

At a point just below the transverse colon an enteroanastomosis is made between the two loops of jejunum (Fig 614) A Levine tube which has already been placed in the esophagus is drawn down into the efferent loop so that its end is well past the enteroenterostomy If the Levine tube is not used, a medium-sized soft rubber catheter which has been passed through a stab wound to the left of the abdominal incision may be introduced obliquely into the jejunum for feeding; this is done according to the method of Witzel, or better, according to a modification of the Coffey principle

This operation is rather prolonged, but by using continuous intravenous solutions and transfusions of blood during and after the operation, shock can be readily combated

All feeding is done through the jejunostomy or Levine tube for two to five days. This gives the union between the jejunum and the esophagus time to heal fairly securely. and the strain of the muscular action from swallowing demands at least this period of rest. The patient may occasionally have a teaspoonful of water by mouth, which is enough to keep the mucous membranes from being too dry. The diet is important and should be supervised by some one skilled in dietetics. It is unnecessary to administer hydrochloric acid, but the food should be easily digestible and given at rather frequent intervals. Many patients in apparently good health have achlorhydria, and the jejunum is particularly susceptible to the irritating action of hydrochloric acid.

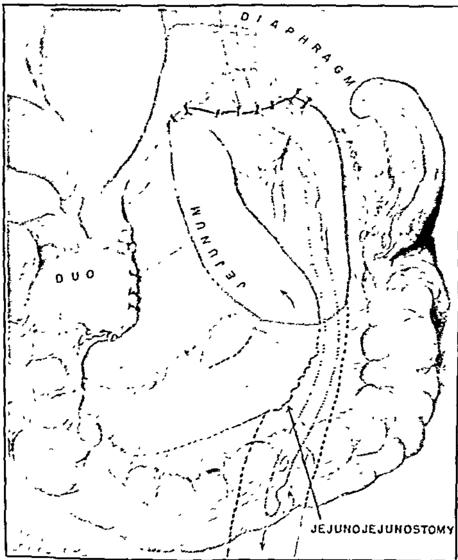



Fig 614—Total gastrectomy. The anastomosis has been completed and an enteroenterostomy has been made just below the opening in the mesocolon.

## THE DEVINE OPERATION

Not infrequently a large fungating tumor of the stomach, which is often a colloid cancer, will give a better prospect for cure than a small cancer which ulcerates and metastasizes quickly W. J. Mayo's apt remark that cancer *coming to you* is less malignant than cancer *going from you*, is real wisdom. However, these large cancerous masses may be found so adherent and extensive around the pylorus as

to defy any reasonable effort at resection. When this is the condition, a type of palliative operation, such as that of Devine of Australia, for certain lesions in the pyloric end of the stomach, or a modification of this technic which has been used by Pack for pyloric cancer, may be adopted. This operation seems to have all of the advantages and none of the disadvantages of gastroenterostomy. Clamps on the stomach are placed, the clamp on the oral side being inserted through a rent in the mesocolon. The stomach is severed between clamps, about the middle of the body of the stomach, leaving ample margin for infolding the pyloric stump. The cardiac end is brought down through the rent in the mesocolon and is sutured to the jejunum somewhat after the manner of a gastroenterostomy (Fig. 615); or both ends

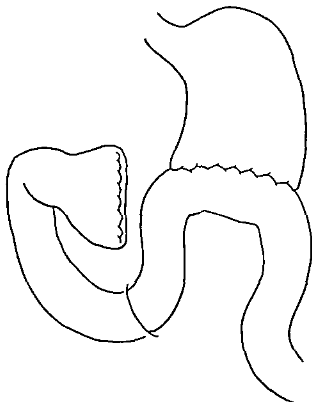


Fig. 615—The Devine operation The stomach has been divided between two clamps, one of which has been thrust through the rent in the mesocolon. The distal stump of the stomach is closed, and the proximal end is united to the jejunum after the manner of a Polya operation If possible, it is then drawn down through the rent in the mesocolon. (From Horsley. Surg, Gynec & Obst 60: 486, 1935)

of the stomach may be closed and then a posterior gastroenterostomy made. If this cannot be done, the jejunum may be united to the stomach in front of the transverse colon and an enteroanastomosis made lower down In this way, the diseased mass at the pylorus is shunted off from the course of the food and given complete rest. In the instances in which the mass proves to be not malignant, permanent recovery may be expected, but even when cancerous the growth of the neoplasm is to some extent retarded by the rest afforded the tissue, and a ready emptying of the stomach is secured

This operation is recommended only when the pyloric end of the stomach and first portion of the duodenum cannot be safely removed It might be justified in certain cases of extensive ulceration, but every effort should be made to remove the ulcer and all of the pyloric portion of the stomach Removal can usually be accomplished satisfactorily by careful, meticulous, sharp dissection

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# CHAPTER 54

# JEJUNAL OR GASTROJEJUNAL ULCER

Guy W. Horsley

Jejunal, or gastrojejunal, ulcer is a bane of gastric surgery. It was formerly called gastrojejunal ulcer, but a careful examination shows in almost every instance that it is the jejunum that is affected by the ulcer and not the stomach, though occasionally the margin of the stomach may be involved.

It is one of the sequelae of gastroenterostomy or partial gastrectomy of the Billroth II type, and though its incidence has been somewhat reduced, it still occasionally occurs even after the most carefully performed gastroenterostomy or resection with the most approved technic.

Jejunal ulcer is usually a late sequela, occurring not earlier than a few months after an operation, and it may be many years before it appears, with an intervening long period of perfect health. While there is no time limit to its appearance, most jejunal ulcers are first found within two or three years after the gastroenterostomy. (Fig. 616.)

Formerly it was thought that nonabsorbable sutures constituted the chief etiologic factor. Not infrequently when a jejunal ulcer was exposed, a silk or linen suture that had been used in the gastroenterostomy was seen imbedded in its base or found dangling from its margin. Catgut sutures were then advocated, and they were used with the expectation that this would eliminate the incidence of jejunal ulcer. However, although absorbable sutures may have had some effect in lessening the occurrence of jejunal ulcer, they have by no means abolished it. The exact number of cases of jejunal ulcer following gastroenterostomy or resection is difficult to determine, partly because this complication varies greatly in different clinics, with sometimes a large incidence even where the technic may be impeccable Then, too, the fact that jejunal ulcer may arise five or ten years or more after the performance of the operation renders it difficult to include all the cases.

Apparently there is some racial or national predisposition to jejunal ulcer. Careful records of the Mount Sinai Hospital in New York, where many of the patients are Jews, show that jejunal ulcer follows gastroenterostomy in at least 30 per cent of the cases operated upon there. In many European clinics jejunal ulcer is common, but, as has been already mentioned, in Europe the inflammation around a peptic ulcer appears to be more extensive than in America The ratio of jejunal ulcer to gastroenterostomy in other clinics, where a large number of these operations are performed, is about 1.6 to 3 per cent

The Mayo Clinic gives a ratio of ten duodenal ulcers to one gastric ulcer, affecting men three or four times more often than women In the recurrent or postoperative form, it is nine times more frequent in men than in women In fact, some authors even make the statement that jejunal ulcer is practically never found in women.

The conditions that predispose toward a recurrent peptic ulcer favor jejunal ulcer. Chief of these seems to be high acidity of the gastric juice. This may be due to the presence of some focus of infection. Though the influence of foci of infection upon the occurrence of peptic ulcer in any form has doubtless been exaggerated, it probably has some influence in developing a chronic ulcer in a lesion that might otherwise escape chronicity. Nervous factors loom large in the etiology of jejunal ulcer and may act not so much directly upon the mucosa itself as indirectly through stimulating the gastric juice and increasing its acidity. This has been noted in the discussion of the etiology of peptic ulcer, particularly in Harvey Cushing's work calling attention to the association of peptic ulcer with lesions of the brain or with some imbalance of the impulses between the parasympathetic and the sympathetic nervous system.




Fig. 616.—Jejunal ulcer on the mesenteric border of the jejunum, following a gastroenterostomy, appearing seven years after the gastroenterostomy.

A careful roentgenologic study of the stomach is valuable in the diagnosis of a jejunal ulcer either because of the filling defect or of the spasm accompanying the ulcer. If there is a fistulous opening into the colon, this, too, is shown and it may be readily confirmed later by a barium enema. Gastroscopic examination is helpful in making an accurate diagnosis, as the ulcer, if present, can usually be readily seen.

It is important to determine so far as possible before operation whether the jejunal ulcer communicates with other viscera. Hemorrhage may follow a jejunal ulcer or the blood may come from the previous peptic ulcer for which the gastroenterostomy was done. The continual presence of high acid qualities in the gastric juice following a gastroenterostomy or gastric resection should always arouse suspicion of a jejunal ulcer.

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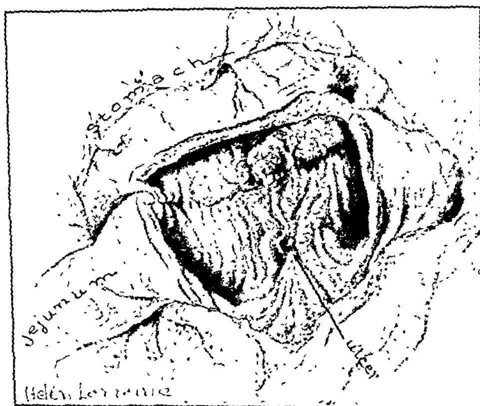



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Peptic ulcer of the duodenum or jejunum rarely becomes cancerous. There are only a few cases of this kind on record. Yet Harry A. Singer reports a carcinoma occurring at the site of a gastrojejunal anastomosis, apparently springing from an ulcer in this region.

A jejunal ulcer is usually not much benefited by medical treatment, certainly not so much as a duodenal ulcer is. Its well-known tendency to burrow and to perforate either into the peritoneal cavity or into an adjacent viscus, particularly the colon, makes it fraught with many dangerous consequences. The best treatment in most cases is operative, and consists first of all in disconnecting the anastomosis. After this has been done, further procedures depend upon the condition of the patient and of the surrounding tissues. Jejunal ulcers that occur after gastroenterostomy can be handled somewhat differently from those that occur after gastric resection. In cases that have had a gastroenterostomy, if the patient's general condition is bad, or if he is rather fat, it will probably be advisable merely to disconnect the gastroenterostomy, suture the stomach and the jejunum, and permit the food to go through the pylorus even at the risk of a recurrent ulcer of the duodenum. In many cases some type of pyloroplasty should be done in order to excise a duodenal ulcer if present or at least to decrease the physiologic obstruction at the pylorus and to permit the free regurgitation of the duodenal contents into the stomach and so lessen the acidity of the gastric juice.

If the patient's condition is good, however, a partial gastrectomy may be done, resecting one-half to two-thirds of the stomach and uniting the stump of the stomach to the duodenum, by one of the modifications of the Billroth I method; or, if the duodenum is so diseased as to make this impossible, some modification of the Billroth II such as the Hofmeister operation may be considered. It must always be borne in mind that the susceptibility of the small intestine to irritation from the gastric juice increases from the duodenum to the colon; and if conditions are satisfactory for uniting the stump of the stomach to the duodenum, this is preferable to the union of the stomach to the jejunum.

Resection of the vagus nerves is also advisable.

## DISCONNECTING A GASTROENTEROSTOMY

The undoing of a gastroenterostomy is sometimes difficult There is no standardized technic for all cases, but certain general principles may be followed and the details treated as the operation proceeds

If the patient is thin, and the gastroenterostomy can be drawn down well below the transverse mesocolon, the transverse mesocolon is opened just above the stoma In most cases, however, it is better to incise the gastrocolic omentum freely. Then, with the left hand, the portion of the stomach involved in the stoma is grasped and pushed down with the transverse mesocolon The first separation should be anterior to the gastroenterostomy; then the dissection proceeds from this point on each side and finally posteriorly Injury to the mesenteric vessels should be avoided. While injury to the smaller vessels anteriorly may not bring serious consequences unless they are close to the colon, division of the larger vessels to the side of or posterior to the stoma is dangerous and sometimes results in gangrene of the colon If one of these large colic vessels is injured, the circulation in the colon at the end of

the gastric operation should be carefully observed. If it is unsatisfactory, the affected segment of the colon should be either resected or sutured into the abdominal wound for observation for a few days.

This dissection is partly sharp and partly blunt with spreading scissors or with gauze. If there is much inflammatory reaction about the jejunum, the tissues are friable and will tear easily, and rough gauze dissection should be avoided. When the gastroenterostomy stoma has been freed on all sides from the surrounding adhesions and the transverse mesocolon, it is packed around with moist gauze and one soft-bladed clamp may be placed on the stomach and one on the jejunum.

What seems preferable, however, is the application of soft rubber bands to the jejunum on each side of the stoma. These bands are the ordinary No. 32 rubber bands and are readily placed around the bowel by thrusting a small hemostat through the mesentery close to the bowel, grasping the rubber band, and tying it three times. This, done on each side of the stoma, leaves more space for manipulation than would the clamp. It does not injure the mucosa, and does not slip if tied at least three times.

With the stoma of the gastroenterostomy isolated and packed around with gauze, it may not be necessary to place a clamp on the stomach. An incision is made in the stomach just above the stoma and about 1.25 cm long. The bleeding vessels are clamped as they are cut and the suction tip is introduced into the stomach, drawing off the liquid contents. The incision is extended, leaving a small ring of the stomach attached to the jejunum. As the division is being made, the contents of the loop of the jejunum isolated between the two rubber bands are also withdrawn When the division has been completed, the stomach wound is sutured with catgut; first a few interrupted sutures of chromic catgut are applied, and as these are held taut the wound in the stomach is closed with a continuous overhand stitch of chromic catgut. This is a hemostatic stitch, embracing the entire wall, and an extra loop is taken where a vessel is clamped. A continuous mattress suture of finer chromic catgut is then applied, burying the inner row of sutures, and finally a series of interrupted mattress sutures of fine chromic catgut is placed The ulcer in the jejunum is excised and the wound is closed at right angles to the long diameter of the opening.

It has been assumed that the ulcer is in the jejunum near the gastroenterostomy opening. If the ulcer is on the mesenteric border, as sometimes happens, it may be necessary to resect this segment of the jejunum and make an end-to-end union. In such close quarters the upper stump of the jejunum is often difficult to approximate and may require a special technic, depending upon the conditions. As a rule, however, the standard methods for end-to-end union of the upper small intestine are applicable.

It will be observed that nonabsorbable sutures are recommended for suturing the jejunum, while slowly absorbable sutures such as chromic catgut are used in the surgery of the stomach itself. As has been remarked before, it seems probable that the part played by nonabsorbable sutures in causing jejunal ulcer has been much exaggerated. They doubtless have some slight irritating effect, but the difference between the incidence of this ulcer after the adoption of absorbable sutures, and when nonabsorbable sutures were employed, is not impressive. At any rate, there seems to be no occasion for adopting absorbable sutures in the small intestine. The highly digestive action of the upper intestinal contents, the thin wall of the

bowel in this region, and the marked peristaltic activity of the jejunum, all seem to point to a condition in which a stable suture that will last until it is extruded into the lumen of the bowel should be used. Sutures in the intestine, as has been pointed out by Halsted, Mall, and others, tend to be extruded into the lumen of the bowel unless they are very superficially placed on the outside. If there is an infection and an external fistula, the fistula will not close until the suture is expelled. If the suture, however, penetrates the entire thickness of the intestinal wall, it is highly probable that it will be thrown off into the intestine If a double row of sutures seems necessary, the inner row should be of nonabsorbable material such as cotton or silk, because this would be extruded into the bowel. The outer row may be of chromic catgut, though this is not so essential in the upper small intestine, where healing is prompt and there is less chance of infection, as it is in the lower bowel, where infection is more common.

## THE OPERATION OF ESTES

Not infrequently a jejunal ulcer is surrounded by much exudate. As has been said, this type of ulcer has a greater tendency to infiltrate than a peptic ulcer in the stomach or in the duodenum has, and it may bind the surrounding tissues of the mesocolon so closely as to make the mobilization at the site of the gastroenterostomy extremely difficult and hazardous. In such instances an injury to one of the larger vessels of the mesocolon is serious, not only because of the devascularization of the colon which this vessel supplies, but because of the difficulty in satisfactorily securing a vessel imbedded in lymphatic and inflammatory exudate.

Estes has described an ingenious operation for handling such cases. Instead of attempting to mobilize the gastroenterostomy, the stomach is liberated as well as possible through an incision in the gastrocolic omentum, incised and detached near the gastroenterostomy stoma, and the wound in the stomach is closed, shifting the gastric current to the pylorus. *The portion of the stomach left attached to the* stoma is also closed. The transverse colon is lifted up, and a lateral anastomosis is made between the two limbs of the jejunum on each side of the gastroenterostomy. In this way, a detour was formed around the ulcerated area (Fig. 617.) It has been well shown by Mann and his associates that after a peptic ulcer has been created in a dog, if the acid contents of the stomach are shunted away from it, the ulcer heals readily.

Such a procedure has much to commend it in the type of cases mentioned. The subsequent treatment would depend upon the conditions A pyloroplasty would lessen the spasm of the pylorus; or a partial gastrectomy uniting the stump of the stomach to the stump of the duodenum might be indicated A subtotal gastrectomy with the anterior Polya-Balfour resection and an enteroanastomosis should be done if the duodenum remains markedly diseased. The proper procedure to be adopted would depend upon the condition of the patient and of the local tissues.

## JEJUNAL ULCER FOLLOWING PARTIAL GASTRECTOMY

Jejunal ulcer may occur after a partial gastrectomy. This theoretically should happen more frequently after a Billroth II type of partial gastrectomy in which the duodenal contents have been shunted from the stoma by an enteroanastomosis. As has been already discussed, the jejunum is more sensitive to irritation by the gastric

juice than the duodenum. If, however, the original operation has been done for ulcer of the duodenum and the gastric current is turned back to the duodenum, the recurrence of a duodenal ulcer is possible. Not infrequently the duodenal ulcer has healed but with so much scar tissue surrounding it as to render the suturing of the duodenum to the stomach inadvisable.

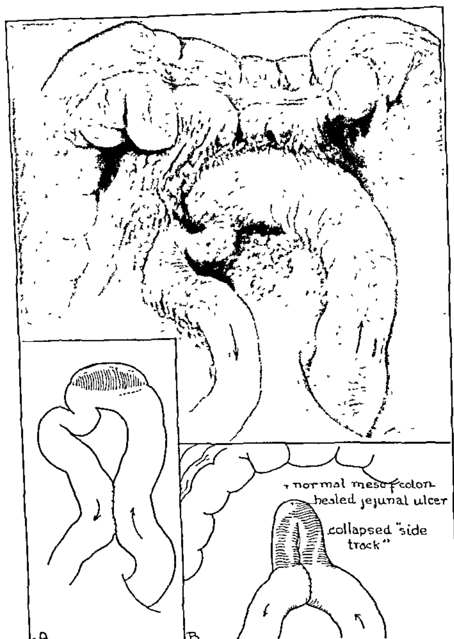



Fig. 617.—The operation of Estes. The drawing shows infiltrated tissue around a large jejunal ulcer. It seemed impossible to mobilize the gastroenterostomy without injuring the large mesenteric vessels. A lateral anastomosis was done as shown in inset *A*. Later the infiltration around the jejunal ulcer was observed to have disappeared.

If an ulcer follows a partial gastrectomy of the Billroth I type, either a further resection with a gastrectomy of the Billroth II type may be done or a posterior gastroenterostomy may be indicated. If a jejunal ulcer arises after a Billroth II operation, a further partial resection of the stomach may give relief, though not infrequently so little of the stomach remains that such a procedure is difficult, and a total gastrectomy seems unwarranted except in a few unusual cases.

## RESECTION OF THE GASTRIC VAGUS NERVES

In view of the increasing interest in the neurogenic theory of the etiology of peptic ulcer, it seems advisable, particularly in jejunal or recurrent peptic ulcers, to resect the gastric vagus nerves, according to the suggestion of Hughson, either on the lower esophagus in the thorax, or just beneath the diaphragm. (See Chapter 49 for description of operative technic.) A jejunal ulcer is practically always accompanied by increased acidity of the gastric juice, which may be caused by an imbalance between the parasympathetic and the sympathetic influences.

According to Friedenwald and Feldman, who conducted a series of experiments on twenty-two apparently healthy dogs: "(1) Section of the left vagus nerve immediately below the diaphragm produces but a negligible change in the gastric secretion as compared with the normal. (2) Following section of the anterior gastric branch of the left vagus nerve, the acidity may remain either normal or become markedly decreased. (3) Section of the principal anterior branch of the left vagus is followed by slight decrease in the gastric acidity. (4) After section of the left vagus in the neck, the secretion continues to be normal or there results a marked diminution in the acidity. (5) Following section of the right vagus nerve, the findings vary but slightly from the normal. (6) It is therefore evident that while at times changes in the gastric secretion occur owing to section of the vagus nerve, these are inconstant; there is likewise a general tendency for this secretion to return to normal when diminished as the result of this operation." These observations made in 1932 have been confirmed by clinical experience in recent years.

Section of the vagus nerves in normal dogs, according to these experiments, shows comparatively slight effect upon the acidity of the gastric juice. It must be recalled, however, that the patients for whom such operations may be indicated in jejunal or in recurrent peptic ulcer would not be normal individuals, but those in whom there is excessive acid secretion in the gastric juice. It seems that resection of the vagus nerves would be more beneficial in those who have this tendency to secretion of highly acid gastric juice, which may be due to nervous influences, than in those who have not this tendency.

Undoubtedly, improper diet, the use of alcohol and tobacco, and probably foci of infection, have something to do with the recurrence of peptic ulcers. Dietetic measures should be carefully followed, obvious foci of infection removed, and the patient instructed not to indulge in either alcohol or tobacco and to lead a less strenuous life. Such a regimen tends to lessen the gastric acidity, but it may be difficult to follow indefinitely. Probably few surgeons or physicians who have been afflicted with a jejunal or a recurrent peptic ulcer would care to adopt it for the rest of their lives. The burden of carrying out these instructions is often greater than they can bear. In such cases, with the probability that there is a neurogenic stimulus causing congestion and erosion and increasing the acid in the gastric juice, it would seem advisable to resect the vagus nerves, in addition to such other local procedures as may be indicated.

## JEJUNOSTOMY

When, however, notwithstanding correct medical regime, operations, and resections, peptic ulcers still recur, and when even resection of the vagi is ineffective, what is to be done? Fortunately, such extreme cases are rare, but that they do oc-

cur will not be denied by anyone with extensive experience in gastric surgery. The suggestion of Balfour that the stomach be given a complete rest for a long time by feeding through a jejunostomy is excellent. The jejunostomy may be done and the stomach given rest for months or even years. Balfour reports cases in which extensive recurrent gastric ulcers with inflammatory exudate apparently disappeared after a few months of feeding through a jejunostomy. If feeding is resumed by mouth later, and the ulcer recurs, it may be necessary to resort to further gastric resection, or possibly to a total gastrectomy.

## JEJUNOCOLIC FISTULA

When the colon is involved in a jejunocolic, or gastrojejunocolic, fistula as a sequela of jejunal ulcer, the situation is still more complicated. The location and extent of the opening in the colon are determined by roentgenologic study. It will rarely be necessary to resect the colon, though of course the closure of the opening is essential. Normally the colon teems with bacteria and a wound in it is prone to be followed by infection. In a gastrojejunocolic fistula, however, the gastric juice usually contains a large amount of acid and the discharge of this acid gastric contents into the colon lessens the number and virulence of the colonic bacteria. The blood supply to the transverse colon is always scant and wounds in the colon heal poorly, so that even with a reduced virulence and quantity of bacteria there is a likelihood of some subsequent infection In many cases, in addition to the use of antibiotics, it is advisable to do a defunctioning cecostomy or colostomy. If this is done several days before the operation on the fistulous tract, disconnecting the anastomosis and resection of the fistula will be easier, and a more radical operation can be successfully carried out. If it has been definitely ascertained that there is a fistulous tract between the jejunal ulcer and the colon, small rubber bands, as have been described in resection of the bowel, are passed around the colon on each side of the fistula. Before tightening one of these bands the segment of colon to be isolated by the bands is stripped to empty it of any remaining contents. If it is possible to do so, this segment is packed around with moist gauze. The fistulous tract near the colon is severed. A few sutures of silk immediately close the opening in the colon. On account of the inflammatory exudate, suturing the opening accurately may be impossible, but the sutures will make at least a temporary closure and prevent spreading infection from the colon during the rest of the operation. The colon is again packed off with moist gauze. The jejunal opening is dealt with according to the indications that have been already discussed, resecting the ulcer and suturing the jejunum transversely, and then closing the gastric wound and making a pyloroplasty, or doing a more extensive gastric resection, according to the circumstances in each case.

Of course it will be indicated to close the opening in the jejunum, but in extremely difficult cases if this closure is not satisfactory, a wide lateral anastomosis between the two limbs of the jejunum circumventing the ulcer, as suggested by Estes, with a temporary packing off of the fistulous tract with gauze, would doubtless be followed by a subsidence of the jejunal ulcer. This, however, is a suggestion only for the exceptional cases in which it appears impossible or extremely difficult to deal with the jejunal ulcer after the fistulous opening into the colon has been separated.

After first temporarily closing the opening in the colon and doing what may be indicated with the jejunal fistula and ulcer, the colon is again taken up. If inflam-

matory exudate into the colon and around the fistulous tract is extensive and does not permit satisfactory permanent suturing, it may be advisable to do a lateral anastomosis in the colon in a somewhat similar manner to that around a jejunal ulcer. Resection should be avoided if possible because the infiltration of the inflammatory exudate into the mesentery not only makes the operation difficult but endangers the healing of the bowel.

The inner row of sutures in the colonic opening is of silk. The outer row of catgut should be interrupted mattress sutures. The ends of the outer row are left long and passed through some adjacent peritoneum-covered fat, probably omentum, and tied, so offering additional protection for the sutured colon.

Injuries and wounds in the colon heal much more slowly and are more prone to infection than wounds in the stomach, and additional precaution should be taken on this account. It is usually best not to use drainage after these operations. The presence of a drainage tube, or particularly of gauze, near suturing of this kind will induce a flow of lymph toward the gauze or tube in nature's effort to expel the drainage material which constitutes a foreign body. This detracts from the flow of lymph that would go to the intestinal wound and take part in the healing process, and so weakens the sutured wound and renders it more liable to subsequent fistula formation If an abscess is present in this region, draining it will be necessary, but the abscess cavity should be so walled off by omentum and surrounding tissue that its drainage tube will not touch the sutured bowel.

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# CHAPTER 55

# OPERATIONS ON THE SMALL INTESTINES

Guy W. Horsley

## ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS

Operations on the intestinal tract usually involve some form of suturing, and it was formerly believed that any type of intestinal suturing was applicable to all portions of the intestinal tract. This, however, is a fallacy, and while the main principles of suturing may hold, there are variations in the technic of operations on the intestine that should depend upon the structure and function of the portion of the intestine involved.

Absorption of the proteins, fats, and carbohydrates takes place almost entirely in the small bowel, particularly in the upper portion of the small bowel. There is very little absorption of any kind in the stomach, except of alcohol. A small amount of water, and probably a trace of highly concentrated dextrose, may be taken up by the stomach, but for general purposes of nutrition of the body this is negligible. The right half of the colon is concerned chiefly with the absorption of water and salts. The left half of the colon is mainly for storage purposes, and while under changed conditions portions of one half may substitute for those of the other, the physiologic function of the left half of the colon for storage and of the right for absorption of water and salts is fairly well marked.

It has been recently a disputed point as to whether the colon can absorb any dextrose, and it seems to be probable that dextrose in a weak solution can be taken up to some extent by the colon, but the chief absorption of dextrose is in the small bowel. While the jejunum and the ileum take up some water, about as much water is excreted into the small intestine in the form of succus entericus and pancreatic and biliary juices as is absorbed

Monks first directed attention to the variations in structure of the small intestine from above downward and devised a method by which the segments of the small intestine can be located with considerable accuracy There is a decided difference in the distribution of the blood vessels and of the fat from the beginning of the jejunum to the end of the ileum, the vessels being more prominent and the fat smaller in amount in the upper small intestine than in the lower. Internally there are larger folds of mucous membrane in the upper small intestine, doubtless an arrangement to present a large area for absorption. The blood and lymph supply in the upper intestine is greater than that in the lower, and far greater than in the colon.

One of the most important considerations in surgery of the small intestines is the difference in the contents of the bowel from above downward. When there is a normal amount of acid in the gastric juice and under usual diet, the hydrochloric

acid secreted by the stomach has such a bactericidal effect that bacteria in the stomach are infrequent. In the duodenum and the upper jejunum, the acid in the gastric juice is neutralized by the alkaline contents of the duodenum, and the inhibitive effect upon the growth of bacteria is lessened. The chief element of the duodenal alkaline contents is the pancreatic juice. As the intestinal content goes toward the ileum, the bacteria increase, and when the terminal ileum and the colon are reached, the fecal matter consists very largely of bacteria. In the colon the growth of the microorganisms reaches its height because of stagnation of the fecal current and the disappearance of the restraining influence of the gastric juice. According to Alvarez, peristalsis proceeds largely according to a gradient in which the motor contractions are more rapid in the duodenum and upper jejunum than in the lower ileum. Muscular tissue from the duodenum from which the nerve supply has been removed contracts at the rate of about 20 times per minute when it is immersed in oxygenated Locke's solution, while a strip of muscle from the lower ileum contracts at the rate of about 10 times per minute.

The upper small intestine is much more sensitive than the lower small intestine, and resents obstruction more than the lower small intestine. After a barium meal the jejunum shows only streaks and spots of barium, because its motor activity rapidly carries the meal to the bowel below. On account of this hypersensitiveness and restlessness the upper small bowel is more quickly affected by a small obstruction than the lower small bowel. Thus, Dragstedt has shown experimentally that the lower ileum will withstand slight pressure that would produce serious obstruction in the upper jejunum. It is, therefore, necessary to provide an ample lumen in operations on the upper small bowel. The inversion of too much tissue, as in the so-called aseptic anastomosis, may produce serious obstruction in the upper jejunum which would not occur from the same amount of inversion of the diaphragm in the lower ileum or in the colon.

## HEALING OF INTESTINAL WOUNDS

After properly applied intestinal suturing, the wound remains fairly strong for the first twenty-four hours. During the next twenty-four hours the wound becomes weaker, then gradually it grows stronger until its resistance equals the normal bowel. The union of the sutured bowel begins by a deposit of lymph formation which is excited by the pressure of the suture, by the trauma of the needle, and by the presence of the thread. In interrupted sutures the pressure between the sutures is very slight, and union depends largely upon the extension of hyperemia and lymph deposits from one suture to the other If sutures are not properly placed or are too far apart, this extension of the lymph deposit may not be adequate and leakage will result. With a continuous suture slight pressure is made on the two approximated serous surfaces along the whole line of suturing. Interrupted sutures, if properly placed and particularly if they are reinforcing a line of continuous sutures, are quite efficient.

The first layer of the intestinal wall to heal is the peritoneum After suturing of the bowel in which the peritoneal surfaces are approximated, lymph exudate is very quickly poured out around the sutures When there is no infection, this lymph deposit is converted directly into fibrous tissue within a few days and there is no intervening granulation tissue (Hertzler) The sutures themselves and the lymph de-

posit hold the bowel together for the first twenty-four hours, but during the second twenty-four hours the hyperemia and infiltration weaken the grasp of the suture, while the deposit of lymph has not become sufficiently organized to give adequate support. The exudate of lymph becomes stronger about the fourth day. From then on there is an increase in the strength of the wound of the sutured bowel, so that in properly applied suturing, the greatest weakness of the intestinal wound is in the second and third days. The peritoneal coat heals first, the next layer to heal is the mucosa, and the muscularis mucosa is the last coat to regenerate. Some observers think it is merely united by a narrow scar and that there is no true regeneration. The margin of the mucosa of the sutured bowel becomes necrotic, though there may be no apparent constriction of the mucosa by the suture. This slough seems to separate about the fifth day, leaving a clean raw surface, and, according to Mall, the mucosa regenerates from the bases of the crypts and in three weeks the regeneration has been complete. The muscular layer regenerates from the margins of the divided muscular coat. The diaphragm which is inverted in suturing eventually straightens out, and all the coats of the sutured intestine are seen to be fully regenerated within two months after the suturing. The regeneration is usually so complete that the line of union often cannot be detected with the naked eye.

## INTESTINAL SUTURING

Lembert, in 1826, first established the fundamental principle of intestinal suturing, namely that the peritoneum along the margins of the wound must be approximated. If, however, the suture grasps only the peritoneal and muscular coats, it may not hold, and Halsted and Mall showed that it was necessary to catch in each bite of the stitch some of the tough submucous layer in addition to the more superficial parts of the bowel. It has been shown by Connell and others that the submucosa, while very tough, is a thin membrane, and, in order to be sure of including it in the intestinal suture, it is necessary to perforate it and, consequently, penetrate the mucous membrane of the bowel. More deaths will occur from the leaking of the suture that does not catch the submucosa than from any sepsis that might follow penetrating the mucosa

Both the interrupted and the continuous sutures have a proper field. A study of intestinal repair after the application of the Murphy button has shown that the healing process following the Murphy button leaves a fine narrow scar which apparently does not result in stricture. Simulation of the conditions which produce this type of scar seems desirable, and can usually be attained more accurately by a continuous suture than by interrupted sutures. Because of the tendency of the Murphy button to act as a large foreign body and to produce obstruction, the use of this device has been almost abandoned, but the narrow scar from the even and continuous pressure on a narrow band of tissue is the ideal result to be desired.

If only one row of sutures is used, the suture should always penetrate the submucosa and catch some of the mucosa in its grasp. Reinforcing sutures which are superficial must not be placed so deeply. The interrupted sutures commonly used are the Lembert suture (Fig. 618) and the mattress suture. There are other more complicated sutures, such as Czerny-Lembert and the Gussenbauer, but they have no particular advantage so far as efficiency is concerned. The sutures can be so placed that the knot is in the lumen or at least partially so. This is done by begin-

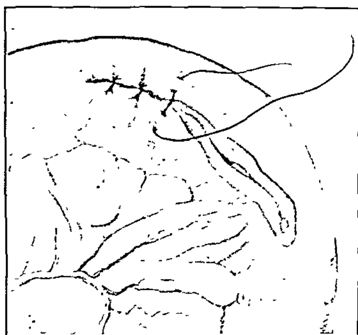


Fig. 618.—Insertion of interrupted Lembert sutures.

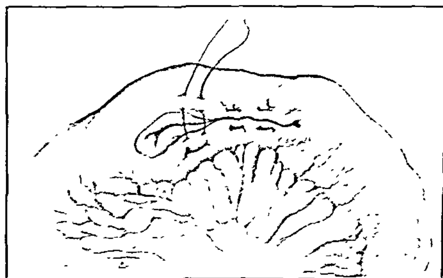


Fig. 619.—Insertion of Halsted interrupted mattress suture. The knots are to the side of the incision.

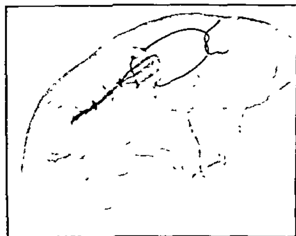


Fig. 620.—Interrupted mattress suture with knots over the incision.

ning the suture near the incision and taking the first bite outward and the second bite from outside inward, toward the mucosa, and tying the knot near the mucosal edge.

Halsted popularized the interrupted mattress suture, which was tied on one side of the wound (Fig. 619). The interrupted mattress suture may also be applied so that the knot will be over the wound (Fig. 620). The knot of the Lembert suture lies over the wound.

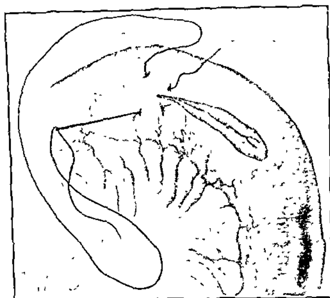


Fig. 621.—The beginning of a continuous suture The needle is in the reverse position from its first insertion, so that when the knot is tied it is partially buried

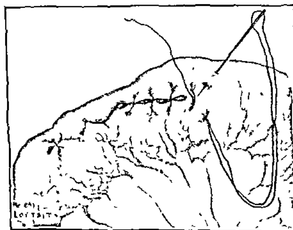


Fig 622 —The ending of the continuous suture, with the needle reversed so that the knot can be partially buried

The continuous sutures that are usually applied when suturing from the outside of the bowel are the overhand stitch and the running mattress or right angle Cushing suture. This latter suture is in principle the same, whether applied from within or without the bowel. It inverts a small diaphragm to assure approximation of the peritoneum, while leaving no unnecessary amount of thread exposed. Tension is applied more nearly uniformly along the loop of the mattress suture than with the regular running stitch or the interrupted Lembert suture. However, hemostasis is not so well assured by this type of continuous suture. Formerly, consider-

able emphasis was placed upon the capillarity of the suture and upon the possibility of drainage of the intestinal contents toward the knot. The lymph products, however, quickly cover over the suture and seem to prevent this drainage, though it is desirable to have as little suture material show on the serous coat as possible and to place the knots of the suture within the lumen of the bowel when this can be done.

If the continuous mattress, or right angle Cushing, suture is drawn too tightly, it may pucker the tissues as a basting stitch would. If this suture is used in resection of the bowel or in any long wound, an occasional backstitch is taken, in this way locking the suture at intervals of every third or fourth stitch and preventing the constricting or puckering effect. The beginning and the ending knot of this suture may often be completely or partially buried. When the suture is started, the needle is pointed away from the wound and outward. The second bite of the needle is in a reverse direction. The knot is tied snugly and the short end is cut close to the knot. With an extra loop of the suture the knot will be effectively buried. When the suture is ended, a reversal of this procedure may completely or at least partially bury the knot, though it is not so readily done as with the first knot (Figs. 621 and 622).

Silk is very satisfactory suture material for the intestines. In the stomach it has been thought that nonabsorbable sutures increase the incidence of postoperative peptic ulcer. It is probable that this apprehension has been much exaggerated, though it is doubtless better in suturing the stomach or in suturing the small intestine to the stomach to utilize absorbable sutures such as chromic catgut. Plain catgut would probably be absorbed too quickly. In the stomach, with its thick walls, at least two rows of sutures are always used when catgut is employed, and a single row of catgut sutures in the upper small intestine with its thin wall seems too risky Many operators, however, have good results from catgut sutures in the intestines.

When a suture can be applied from within the bowel, a continuous overhand stitch or a continuous lockstitch is quite satisfactory, though a continuous mattress suture will appose a broader diaphragm If a continuous mattress suture is used from the inside of the bowel, it would be well to reinforce the sutured segment along the mesenteric border with a more superficial layer, as a continuous overhand suture, uniting the actual cut margins of the mucosa Sutures that penetrate the whole wall of the small bowel tend to work into the lumen of the bowel eventually, though the superficial sutures that do not penetrate the submucosa and mucosa may sometimes be encapsulated.

In suturing the bowel where infection is likely to occur, as in the lower small bowel and in the large bowel, the inner row should always be of silk, though the outer row of sutures is preferably of fine chromic catgut If infection occurs and an abscess results, the outer row of sutures, if of nonabsorbable material, will act as a foreign body, while catgut would be absorbed.

If the bowel to be sutured can be readily delivered into the wound, the ordinary straight cambric swing needle and a thimble are adequate for placing the sutures. Not only is the thimble useful in inserting the suture, but it protects the rubber glove from puncturing. When the bowel is difficult of exposure and the mesentery is fat, a curved needle sometimes called a French needle, or a larger curved needle than this without a cutting edge but with a thin body, should be used. The atraumatic needle attached to the suture seems to be preferable, since it produces less trauma and is less likely to tear the mucosa.

## COPROSTASIS

There are numerous means by which the fecal current is controlled during an operation on the intestine. One of the best is the use of small rubber bands passed through the mesentery of the bowel and tied just tight enough to occlude the lumen. A stationer's small rubber band, No. 32, is drawn through the mesentery near the border of the bowel with sharp-pointed hemostatic forceps and is tied gently. This will make complete coprostasis without injury to the mucosa. Such a band can be readily tied around the finger without pain, and it has been used in segments of bowel that were to be resected in order to observe whether the mucosa was injured, and after resection no injury to the mucosa could be found. It is wise to place a small hemostat on the end of each rubber band for identification purposes. When the operation is completed, the bands are cut and removed. Where the application of a band is difficult, or where a lateral incision is to be made as in an enterostomy, a soft-bladed clamp is the best method of coprostasis. The bowel should be well stripped of its contents before the application of the bands or the clamp. If the clamp is well made, it may be applied without placing rubber tubing over its blades. If it is curved, the lock should be accurate or the blades may override and cut the bowel.

## INTESTINAL FISTULA

An important feature of surgery of the small intestine is the treatment of intestinal fistula. An intestinal fistula may be external, through the abdominal wall, or internal, communicating with another viscus, as the gall bladder, the stomach, or the colon. The internal type is usually of no serious consequence. An internal fistula is often the result of an operation in which there is purposely made a communication between the gall bladder and the intestine. An opening between the common duct and the duodenum may also be instituted when there is a stricture or obstruction in the distal portion of the common duct with a previous cholecystectomy. If there is a fistula between the duodenum and the lower ileum or colon, malnutrition may result because of shunting the nutritive contents of the duodenum around the chief absorptive portion of the small intestine.

An external fistula results from trauma, either from a surgical operation, from perforation of an ulcer that has formed an abscess and opened externally, or from external violence, such as stab or bullet wound. This type of fistula often very seriously affects nutrition.

An external duodenal fistula may follow operations upon the duodenum, the stomach, the common bile duct, or the right kidney. The duodenum lies over the upper portion of the right kidney, and in nephrectomy while clamping and tying the vessels of the renal pedicle the duodenum may be injured unless care is taken to avoid this complication. If the duodenum is not opened at the time of operation, crushing its walls with the forceps sometimes causes a fistula later. A sutured wound in the duodenum may break down Operations for removal of stones from the common duct when there is much surrounding exudate and inflammation occasionally result in duodenal fistula. Even when the duodenum is not directly injured in such operations, the pressure of the drainage tube on it sometimes causes a fistula. Omentum or adjacent peritoneum-covered fat should always be sutured over the duodenum in order to protect it from the pressure of a tube. A foreign body, the

tube, diverts the lymph toward it and is nature's effort to extrude the foreign body. Thus the lymph, instead of being utilized for repair of the inflamed or injured duodenum or the sutured tissue, is dissipated, and the slight pressure of a tube may cause necrosis of the bowel wall under these circumstances. The placing of a tube down to the stump of the duodenum after a partial gastrectomy also predisposes to a duodenal fistula. A cigarette drain containing gauze is even more likely than a tube to produce a fistula where there is inflammation or an injury to the duodenum, because it induces an even stronger flow of lymph toward the drainage than does the rubber tube.

If a duodenal fistula follows a lumbar nephrectomy or the rupture of a posterior duodenal ulcer, it is always extremely serious. The loose retroperitoneal areolar tissue presents a large area for infiltration. The digestive action of the duodenal fluids and the decomposition of partly digested food furnish abundant toxic products for absorption, and the loss of the alkaline values of the pancreatic juice is detrimental.

The diagnosis of an external duodenal fistula in the early stages is not always clear. When it follows drainage of the common duct, the secretion changes and in addition to bile there is a moderately profuse flow of bile-tinged fluid irritating the surrounding tissues It may appear after a Billroth II type of gastrectomy when there is an abscess or infection in the abdominal wound. After a walled-off abscess around the duodenum, pus usually appears first, and later duodenal contents may be seen. If a duodenal fistula is suspected, the oral administration of methylene blue or some kind of food readily expelled, such as egg white colored with methylene blue, usually makes the diagnosis obvious.

The treatment of an external duodenal fistula depends upon the general condition of the patient as well as upon the size of the fistula. If the fistula appears several days after a drainage tube has been placed in the common duct, and the tissues around the drainage tube are well walled off, making a straight canal, the tube should be withdrawn and the abdominal portion of the fistulous opening brought together as closely as possible with adhesive plaster or probably by suturing. The tract will doubtless not be immediately closed in this way, but its size is diminished, and less of the duodenal contents will come through the fistula If the wound is large, and particularly if sepsis is present, as often occurs in these fistulas, a complete closure of the portion of the tract through the abdominal wall should not be carried out, for this would cause the formation of pockets and promote the extension of sepsis.

In a fistula with sepsis, the discharge may be drawn off with a tube, such as a rubber catheter with an additional opening, connected with continuous suction When the discharge greatly lessens and the wound appears healthy, the suction is discontinued and the superficial portion of the wound is brought together with adhesive plaster.

In a small duodenal fistula when the nutrition of the patient is not seriously affected, the skin should be protected with zinc oxide ointment or aluminum paste and the wound frequently dressed The use of beef peptone has been advocated on the theory that it acts as a buffer for the duodenal contents and so lessens the irritation on the surrounding tissues The formula for this mixture is as follows: Bacto brain veal broth, dehydrated, is used by dissolving 37 grams in 1,000 c c of 0 1 normal hydrochloric acid and sterilizing this solution in the usual manner; or 13 grams

of Bacto dextrose broth, dehydrated, may be dissolved in 1,000 c.c. of 0.1 normal hydrochloric acid. To prevent hemolysis 8 grains of sodium chloride per liter should be added. A dam is built up around the fistulous opening with zinc oxide ointment and petrolatum. A piece of gauze saturated in the broth is placed in this crater, and is changed as often as necessary.

When, however, the fistula is sufficiently large to permit most of the duodenal contents to escape, such treatment is not applicable because a large and continuous loss of the pancreatic juice, bile, and food will seriously impair nutrition. In this type of cases some operation is indicated The kind of operation to be done depends upon both the general health of the patient and the local conditions. A gastroenterostomy with occlusion of the pylorus is often satisfactory, though in a very sick patient such an operation may be too serious It is impossible successfully to suture the duodenum when its walls are infiltrated with inflammatory products.- However, if the fistulous opening is exposed, omentum may be brought over the wound and sutured with at least a prospect of lessening the amount of discharge. This should be done only in connection with some other operation, as gastroenterostomy with occlusion of the pylorus.

A Miller-Abbott tube may be passed down well beyond the fistulous opening, and, keeping the balloon deflated, the patient is tube fed. This cuts down on the fistulous drainage and may tide the patient over the critical period until the fistula heals. If the fistula is in the jejunum, an enterostomy may be done below the opening and the patient fed by this route.

If the discharge is very profuse, the use of suction will prevent damage to the surrounding tissues, but the loss of intestinal fluids will seriously affect the nutrition of the patient. If there is no obstruction about the pylorus, a jejunal tube through the mouth or nose may be satisfactory. If, however, the pylorus is closed, as after a partial gastrectomy by the Billroth II method, this procedure, of course, cannot be followed. The fistulous tract may be so large or the surrounding inflammatory exudate may produce such pressure upon the gastrointestinal tract that it will be impossible for the tube to follow into the jejunum even when there is no mechanical obstruction at the pylorus. Under such circumstances, a gastroenterostomy is often indicated, with closure of the pylorus with a kangaroo tendon ligature, tied just tightly enough to occlude the lumen and not to injure the tissues. In a very ill patient, however, this operation may be too dangerous and a jejunostomy performed by the oblique method, exposing the submucosa, laying the catheter upon it and suturing the intestinal wall over the catheter, or simply burying the catheter obliquely with the whole thickness of the jejunal wall, or inserting a mushroom catheter (Hendon), is appropriate.

In one case, after futile attempts to reduce the size of a large fistula by strapping the abdominal wall, and when it was apparent that the patient was losing nutrition rapidly, a jejunostomy was done in the left upper abdomen under local anesthesia A catheter was inserted obliquely as has been described, and the patient was fed through it. Probably on account of the inflammation and exudate around the duodenum below the fistula, there was still an abundant though somewhat lessened discharge of the duodenal contents through the fistula. With zinc oxide ointment a well was built up around the fistulous opening. This may be reinforced with a large, soft, circular rubber ring, such as a large, soft, ring pessary (Fig. 623). The

contents were drawn out of this well as it accumulated and transferred immediately to the jejunostomy tube. The patient was also fed through the jejunostomy tube. After the fistula had contracted to some extent, the patient was given food through the stomach, and the partially digested food that came through the fistula was collected and injected into the tube. A small funnel or syringe barrel may be connected with the jejunostomy tube and fastened to the bed or a stand so that the bottom of the funnel is just above the abdominal wall. This will prevent regurgitation of liquid contents through the tube, while gas can escape.

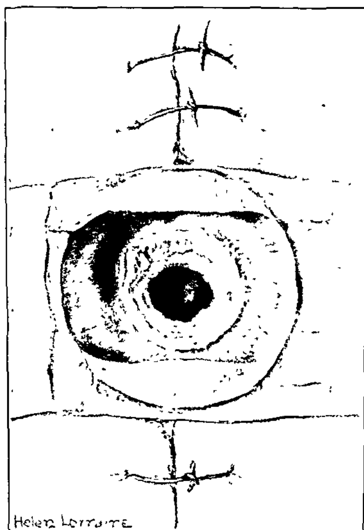



Fig. 623.—This shows the arrangement for catching the duodenal secretions in a large duodenal fistula. The wound has been surrounded by zinc oxide ointment and on this is placed a soft rubber ring pessary, held down by pressure from adhesive plaster.

The extensive loss of duodenal contents and particularly of pancreatic juice is always serious. According to the experimental work of Walters, and of Walters and Bollman, animals live but little longer when all of the pancreatic juice is lost than they would live after complete upper intestinal obstruction. This deleterious effect may be partly overcome by the intravenous administration of Ringer's solution, usually *with 5 per cent* dextrose, as has been described *It should be used as an adjuvant* to other treatments of duodenal fistula. However, there are other elements besides the alkaline salts in the duodenal contents which it is well to preserve. While the loss of bile has but little serious effect upon nutrition, unless continued for

a long period of time, its presence in the gastrointestinal tract undoubtedly aids digestion, particularly the digestion of fats.

Certain persistent and difficult intestinal fistulas may be healed or definitely improved by total intravenous alimentation. Hull has shown that drainage from these fistulas is usually controlled within two or three days after starting this type of treatment. He recommends the daily administration of 3 liters of 10 per cent dextrose and 1 liter of casein hydrolysates to which have been added 10 Gm. of sodium chloride, 3 Gm. of potassium chloride, and 5 c.c. of desiccated crystalline B vitamins with 500 mg. of vitamin C. During this treatment absolutely nothing is given by mouth, which brings peristalsis to a complete standstill. Patients may be maintained in equilibrium by this method for as long as twenty-one days.

## DUODENOTOMY

It may be necessary to open the duodenum for the treatment of a lesion, as the excision of a tumor, the removal of a cancer of the ampulla of Vater, the extraction of a stone impacted in the end of the common duct, or excision of a diverticulum.

Tumors may be resected through a duodenal incision Frequently they are in the first part of the duodenum and are more accessible through a pyloroplasty incision.

If the ampulla of Vater must be exposed for the extraction of a stone or the removal of a neoplasm, the duodenum is mobilized and packed off with moist gauze. A transverse incision is less likely to result in narrowing of the lumen of the duodenum than a longitudinal incision and should usually be employed. If, however, it appears that it will not give sufficient exposure, a longitudinal incision may be made. The type of incision depends upon the local conditions, particularly upon the size and situation of the duodenum. If the duodenum is large, there is no objection to a longitudinal incision. If the tissues are difficult to expose, a longitudinal incision will be indicated; but, other things being equal, a transverse incision is somewhat better. Most stones in the distal portion of the common duct can be either withdrawn or pushed into the duodenum through an incision in the common duct. If the stone is too firmly fixed for either of these manipulations, the end of the duct containing the stone is grasped with the thumb and finger of the left hand, and pushed into view through a duodenal incision. As an additional aid a probe introduced through the incision in the common duct may be used to force the stone toward the duodenum. Very often there is a stricture at the ampulla of Vater, and it will be necessary to cut the mucosa and some of the muscular layer of the duodenum before the stone can be delivered. After removal of the stone no sutures are applied to the ampulla, but any bleeding points are whipped over with fine catgut. If there is a neoplasm at the ampulla of Vater, excision is indicated, or if it is malignant and too extensive for excision, radium should be used. Irvin Abell very ingeniously applied radium to a cancer in this region, by incising the duodenum, inserting needles containing radium into the neoplasm, and tying the needles to a duodenal tube that had been introduced through the stomach and into the duodenum so that the radium could be withdrawn after there had been sufficient exposure. However, emanations of radium in capillary tubes, inserted into and around the neoplasm, are preferable, though the growth is often discovered when these implants are

not available at the time of operation. If the diagnosis is made before the operation, which is unusual, the implants can be secured in advance, but as metallic radium is more easily obtainable in an emergency, the procedure of Abell should be borne in mind. If the lesion is malignant and resectable, one of the modified operations of Whipple, as described in Chapter 63, should be carried out.

The closure of the wound in the duodenum is important. The margins of the incision are united with a continuous suture of silk, taking only small bites of tissue. Over this is applied a series of mattress sutures of fine chromic catgut, the ends of each suture being left long. After all of the sutures are tied, the ends may be threaded in a needle and passed through some peritoneum-covered fat such as the gastrocolic omentum, the great omentum, or fat from the round ligament of the liver, and tied. This procedure adds greatly to the security of the wound.

These wounds should not be drained, as drainage tends to cause a fistula. However, if the operation has been done for a stone in the common duct and there is sepsis, it may be necessary to drain the common duct.

A procedure which is satisfactory when stones have been removed through an incision in the common duct and which somewhat protects the duodenum from fistula is that of inserting the distal portion of a No. 14 catheter into the common duct and then suturing the common duct.

## DUODENOJEJUNOSTOMY

If there is obstruction at the terminal duodenum which cannot be permanently relieved, a lateral anastomosis between the dilated duodenum and the jejunum is good therapy. It is done in somewhat the same manner as a gastroenterostomy. While the normal duodenum is sometimes difficult to expose through the transverse mesocolon, the indications for a duodenojejunostomy are based upon an obstruction in the terminal duodenum which causes a dilatation of the duodenum and makes it readily accessible.

The transverse mesocolon is lifted up, and the dilated duodenum is identified (Fig. 624). Patients with obstruction at the terminal duodenum are usually thin and there is not much fat in the mesocolon. A point in the mesocolon is selected that is free from blood vessels, and an opening is made in it as in the preliminary stages of a posterior gastroenterostomy. After an ample portion of the duodenum has been exposed, the posterior margin of the rent in the mesocolon is sutured to the duodenum with fine catgut. However, the mesocolon may often be treated merely as the peritoneal layer of the duodenum A loop of jejunum is selected a short distance from its origin but at such a point that there will be no tension or kink when the jejunum is placed beside the duodenum. With two interrupted sutures of fine chromic catgut about 6 25 cm apart, the loop of jejunum is attached to the duodenum, and the ends of the sutures are left long for traction. The surrounding tissues are carefully packed off with gauze While holding the tractor sutures taut the jejunum is united to the duodenum with a continuous right angle suture of 00 chromic catgut as in a gastroenterostomy. Manipulation of the tractor sutures aids materially in exposing satisfactorily the site of the operation An incision about 1.25 cm long is made into the duodenum a short distance from the suture line. The contents of the duodenum are withdrawn by suction The bleeding vessels are clamped. The incision is extended until it is about 5 cm in length. The approxi-

Fig. 624.

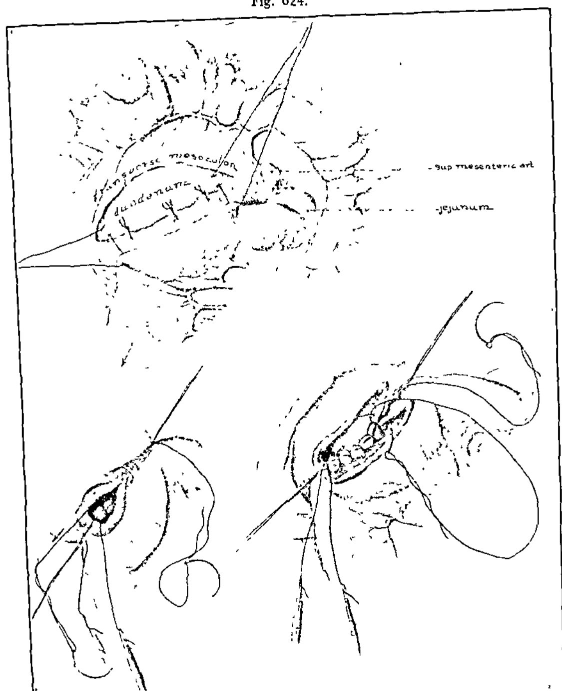



Fig. 626. Fig. 625.

Fig 624.—The transverse mesocolon is lifted up and the dilated duodenum readily shows through the mesocolon. The loop of jejunum is selected for the anastomosis so that there will be no kink or obstruction on its oral side.

Fig. 625.—The tissues have been packed around with moist gauze and the duodenum and jejunum have been united with a row of continuous mattress sutures. An incision has been made in the duodenum and jejunum and the posterior margin of the wound in the jejunum is united to the posterior margin of the wound in the duodenum with a continuous lockstitch of chromic catgut

Fig 626.—This inner row of sutures is applied anteriorly and is drawn taut as it emerges from the mucosa of the duodenum, as described in the operations for gastroenterostomy and partial gastrectomy. This tends to invert the margins of the wound and at the same time secures hemostasis

mated jejunum is similarly incised. The posterior margin of the wound in the duodenum is sutured to the posterior margin of the wound in the jejunum with a continuous lockstitch of 0 chromic catgut. This suture also secures the bleeding points that have been clamped (Fig. 625). The suture begins on the right side and, as it reaches the left extremity of the wound, is carried anteriorly, as in gastroenterostomy. As it emerges from the mucosa of the duodenum in the anterior margin of the wound, it is drawn taut while the wound just behind the suture is gently pressed upon with the finger (Fig. 626). When the suture reaches its point of commencement, it is tied to its original knot.

The first row of sutures is again taken up and carried anteriorly as a right angle continuous suture with an occasional backstitch and is tied to its original knot. A few interrupted sutures of fine catgut are placed at the ends of the wound. The transverse colon is replaced, and the intestines are inspected to determine whether there is any unusual kink or tension not only at the site of the anastomosis but between the anastomosis and the origin of the jejunum. If the loop of jejunum has been properly selected, any complication in this respect should have been avoided.

Cholecystoduodenostomy, choledochoduodenostomy, and excision of the duodenum with the head of the pancreas are described in Chapters 62 and 63.

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# CHAPTER 56

# OPERATIONS ON THE SMALL INTESTINES (CONTINUED)

Guy W. Horsley

## INTESTINAL PERFORATIONS AND WOUNDS

In intestinal wounds from a pistol, a rifle, or a knife, there are often multiple lesions. If there appears to be injury elsewhere than at the wound of entrance, it will be safer to inspect all of the intestines after suturing the obvious wound. In the lower abdomen, coils of small intestine are numerous. A wound in this region calls for a thorough examination of the portion of the intestine that normally resides in the lower abdomen. The closure of such a wound is made, using two purse-string sutures, the first inserted along the margins of the wound and the second burying the first suture. A long wound made by a bullet or shell fragments may have macerated and torn margins. These are trimmed away before the suturing. If the caliber of the bowel is small or the wound long, the wound had best be sutured transversely so that the lumen will not be too greatly constricted. If the longitudinal wound is not very extensive, suturing it at right angles to the axis of the wound can be done somewhat as a lateral anastomosis.

In old wounds where there are fistulous tracts and inflammatory infiltration, a lateral anastomosis is often indicated, so making a short-circuit around the diseased segment of bowel. In certain jejunal ulcers where there is much infiltration into the adjacent mesocolon and where mobilization of the jejunum may involve injury to the colic vessels, a lateral anastomosis around the ulcer, if the proximal loop of jejunum will permit it, may often be the best procedure.

When a lateral anastomosis is indicated, the two loops of bowel to be united are selected, stripped of fecal contents, and small rubber bands are applied to the ends of each loop. If the bowel cannot be well exposed, soft-bladed clamps may be used for coprostasis. The intestinal loops laid side-by-side are united with a continuous suture of catgut or silk in a straight or curved needle, depending upon the exposure. When the bowel is rather inaccessible, a curved needle is more satisfactory. The suture may be placed as a continuous mattress or as an overhand stitch for a distance of about 5 or 6.25 cm. If a continuous mattress stitch is used, it should be locked at intervals of every three or four stitches with a backstitch. The suture is then temporarily discontinued. The surrounding tissues are well packed off with moist gauze. About 0.6 cm. from the suture line, an incision is made in one loop of bowel about as long as the row of sutures. The open bowel is cleaned by suction and sponged out with strips of gauze that have been soaked in mercuric iodide solution or some mild antiseptic. A corresponding incision is made in the opposite loop of the bowel, and the posterior margin of the wound on one side of the bowel is sutured to the posterior margin of the wound on the other side with a

continuous lockstitch of silk in a curved needle. The suture is drawn snugly as it is applied. This stitch begins at the point where the first line of sutures was temporarily abandoned. After these posterior margins have been united, the anterior borders are approximated by continuing the suture anteriorly, applying it as far as possible from within, as already described, by drawing it snugly only as it emerges from the mucous membrane on the left-hand side of the wound, while the tissue just behind the suture is pressed on with the finger. If the bowel is thin, two or three bites of the suture may be taken loosely before drawing them taut, and traction should be made in the axis of the suture line. If the suture is tightened as it emerges from the peritoneal side, the margins will not invert. The suture is continued to the point where the first knot in it was tied, and it is then tied to this original knot several times. Both ends are cut short. The first continuous suture is then carried anteriorly in the same manner as it was inserted posteriorly, and it is tied to its original knot. At each end of the wound a few interrupted sutures are placed for additional strength, and a few sutures may also be inserted along the middle of the wound. These act somewhat as a buffer for the action of the peristalsis.

The outer row of sutures should not be drawn too tightly. The inner row is hemostatic, and may be placed quite snugly because tissue within the grasp of this suture will have its nutrition cut off and will separate or become absorbed. In the outer row of sutures the nutrition of the approximated bowel should be maintained, and if the knots in this row are tied too tightly, necrosis may occur and leakage will result. The internal row of sutures has external to it the adherent peritoneum which will prevent leakage The outer row has no such protection, and the whole wall of the bowel, including the peritoneum, may be involved in the necrosis following tight external sutures

If the wound is rather long, however, and particularly if the bowel is infiltrated as after undoing a gastroenterostomy, a somewhat different procedure may be indicated. The bowel should be mobilized as much as possible, so that it can be readily folded on itself At a distance of 5 cm. from the end of the wound, small rubber bands are applied, as has been already described. The bowel is cleansed and a suture of silk is placed from one extremity of the wound to the other. This is tied and the ends are left long as a tractor suture. This suture divides the wound into two equal parts If there is much infiltration, it would be best to apply a series of interrupted mattress sutures of silk, tying them on the mucous membrane. If, however, the bowel wall is about normal, the suturing may be done as already described by beginning it at one angle, inserting a silk suture from the mucosa on one side and through the other side from the peritoneal surface to the mucosa. This is tied snugly and the suture is continued, being applied as far as possible from within and drawn snugly as it emerges from the mucosa on the left-hand side. This is carried up to the tractor suture A similar suture is begun at the other angle of the wound and is also carried up to the tractor suture, where the two sutures are tied several times together If this type of suture cannot be readily applied as a first row, a simple overhand stitch catching a small margin of the wound will be satisfactory The inner row of sutures is buried with a continuous overhand or mattress suture of chromic catgut. It would be well to reinforce these sutures at intervals with interrupted mattress stitches.

Closure in this manner is quite satisfactory. Though it is irregular in contour and may not appear to restore the shape of the bowel, the approximation of the two extremities of the wound where the circular muscles are intact provides adequate peristaltic movements, and the longitudinal fibers, some of which along the mesenteric border have not been interrupted, seem to function satisfactorily. If the mesenteric border is extensively involved in the pathologic process, a resection with end-to-end union should be done.

## DIVERTICULA

Diverticula of the small intestine are doubtless more common than the records would show. Diverticula of the duodenum are not infrequently demonstrated in roentgenologic examinations. Diverticula of the jejunum are usually encountered incidentally during operations, but they may be a source of local peritonitis or may actually rupture. It seems strange, however, that these diverticula, which are exceedingly thin and apparently with little or no muscular coat, usually cause so little discomfort. Doubtless the liquid character of the stool, the relative freedom from bacteria, and the rapid motion of the upper small intestine prevent serious trouble which somewhat more frequently follows diverticula in the large bowel, where the fecal contents are less liquid and where bacteria abound and the intestinal movement itself is more sluggish and less efficient in emptying these pockets. The diverticula in the upper small intestine are usually along the mesenteric border and seem to project from the apertures caused by the penetration of the bowel by blood vessels from the mesentery If a diverticulum can be isolated, its neck carefully freed down to the margin of the bowel, and a simple ligature of silk tied on the neck, the diverticulum may be clamped and severed and the stump disinfected with pure carbolic as in appendectomy. It would be best, however, to draw some peritoneum over the stump with a suture. If the diverticula are extensive, resection of the affected segment may be demanded, but in the absence of clinical symptoms of inflammation, it would be doubtful whether such an operation as resection of a loop of bowel merely because of the presence of diverticula, without symptoms or complications, would be justified.

Duodenal diverticula which are large and retain food particles or barium following a gastrointestinal x-ray study may produce symptoms and warrant excision. Those in the second portion of the duodenum may be difficult to locate. The best approach is to expose the duodenum as carefully as possible, with the assistant pulling the bowel toward the midline. The peritoneum over the duodenum is divided and the duodenum rotated forward and medially. In this way the posterior and medial surface of the duodenum can be readily inspected Here, as in looking for other diverticula, compression on the bowel will cause filling of the lumen of the diverticulum and its easier recognition Once the diverticulum is located, it is carefully dissected out from the surrounding structures and then excised. The technic of excision is essentially the same as for solitary diverticula of other parts of the alimentary tract and as illustrated for the removal of Meckel's diverticulum.

Meckel's diverticulum is a structure that results from the imperfect absorption of the vitelline duct, and its presence may give rise to obstruction or to local peritonitis, perforation, or hemorrhage The tip of a Meckel's diverticulum may be

free (Fig. 627, *A*) or attached to the abdominal wall or to other structures. The *presence of gastric mucosal tissue has been demonstrated in Meckel's diverticulum,* and peptic ulcers of the adjacent portion of the ileum may consequently arise. Ulcers may also occur in the diverticulum itself, with local peritonitis or with actual perforation.

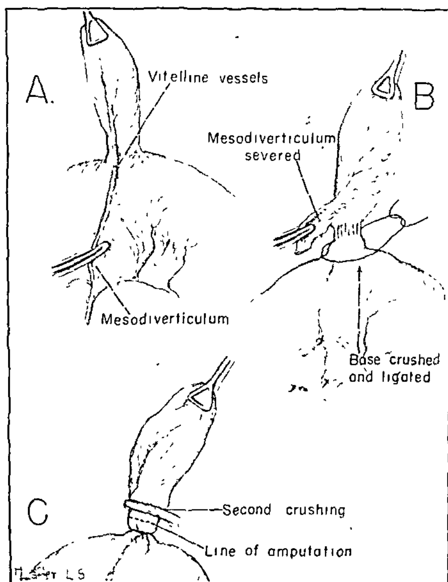



Fig. 627.—*A*, A narrow-base Meckel's diverticulum showing the vitelline vessels and the mesentery to the diverticulum *B*, The mesentery has been divided and the diverticulum crushed *C*, The diverticulum has been ligated, the dotted line shows where it will be divided

The technic of excision of Meckel's diverticulum depends to a large extent upon the size of the diverticulum. If it has a narrow base and is long, the treatment may be somewhat like that of the stump of the appendix, ligating and dividing the mesentery to the diverticulum (Fig. 627, *B*), ligating the neck of the diverticulum, and excising the diverticulum (Fig. 627, *C*). The ligature should preferably be of silk or chromic catgut. The stump is disinfected with pure carbolic If the stump is narrow, no further treatment is necessary Usually, however, the neck of the diverticulum is broad and the actual lumen of the intestine opposite the diverticulum is narrow. In such cases it is very easy to impinge too greatly upon the lumen of the bowel by

folding in the stump of the diverticulum. Therefore, the loop of bowel containing the diverticulum is isolated, as though resection were to be done, placing small rubber bands on the loop on each side of the diverticulum. Before the last rubber band is tied, the intestinal contents are stripped from the loop. The diverticulum always has some mesentery. This is clamped and divided (Fig. 628, *A*) and tied with catgut. The base of the diverticulum is clamped about 1.25 cm. from the level

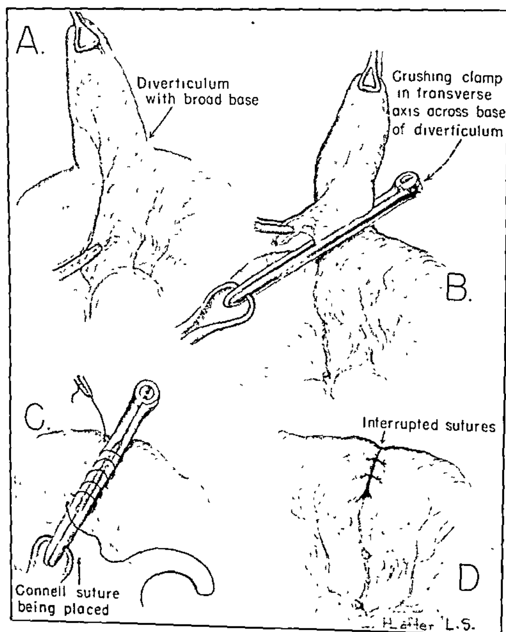



Fig 628—*A*, A wide-base [illegible] tery has been divided and the b [illegible] *B*, The mesen- been removed and its base sutur[illegible] diverticulum has [illegible], Additional interrupted sutures of catgut or silk are being placed to reinforce the suture line.

of the bowel and is divided with a knife or electric cautery (Fig. 628, *B*). A basting stitch of silk is applied over the clamp as in the method of aseptic intestinal anastomosis, and the two ends are drawn taut as the clamp is gradually removed (Fig. 628, *C*). In this way the raw surface is inverted and the pedicle usually does not open, for the pressure of the clamp makes it adhere. The bowel, however, should have been thoroughly packed around with moist gauze, because in spite of care the

pedicle may open. One end of the basting stitch is doubled back as a continuous overhand or right angle suture and tied to the original end. A few reinforcing interrupted mattress sutures of catgut or silk are placed for further security (Fig. 628, *D*).

## ENTEROSTOMY

In the small bowel an enterostomy is usually made for relief of actual or potential obstruction, or for feeding. Many technics have been devised for enterostomy. A direct puncture with a knife or cautery into a distended loop through a part of the intestinal wall that has been surrounded by a purse-string suture has advocates

In the method of Hendon, a mushroom catheter is inserted through a small perforation in the bowel surrounded by a purse-string suture (Figs. 629 and 630). A second purse-string suture of fine chromic catgut is inserted and its ends are passed through the parietal peritoneum near the stab wound. The butt end of the catheter may be drawn through a stab wound in the abdominal wall before the catheter is placed in the bowel. After it is inserted into the bowel lumen, the catheter is pulled upon until the bowel is held snugly against the parietal peritoneum (Fig. 631).

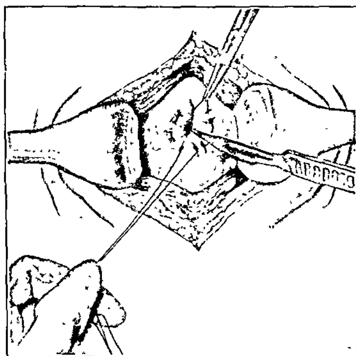


Fig. 629.—The first stage of Hendon enterostomy. A purse-string is inserted and the bowel is punctured with a sharp-pointed knife.

Particular attention is called to the method of disposing of the mushroom catheter when the enterostomy is to be discontinued. Instead of pulling out the catheter and so probably causing some injury, the catheter is cut flush with the skin and the mushroom end is pushed into the bowel As in this technic no suture is taken through the catheter, the end of the catheter should be readily dislodged into the bowel This method seems peculiarly adapted to enterostomy for feeding where the bowel is collapsed, because the oblique infolding method in a small bowel may produce obstruction to the portion of the bowel on the oral side of the enterostomy, whereas with this technic no material obstruction is caused as the mush-

room end of the catheter has a double perforation and there is only slight infolding by the purse-string suture, just enough to bring the serosal layer snugly around the catheter. This is a simple method of enterostomy.

Another method which is satisfactory in the small intestine is the oblique enterostomy after the principle of Witzel. When there is much distention in the bowel, a direct opening into its lumen may produce a large fistula difficult to close.

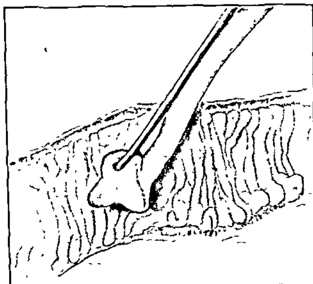


Fig 630.—The second stage of the Hendon enterostomy. The purse-string suture is held up under tension to avoid spilling the intestinal contents. The small puncture wound is dilated by insertion of a closed hemostat, and while the hemostat is opened a mushroom catheter guided by a uterine probe is introduced.

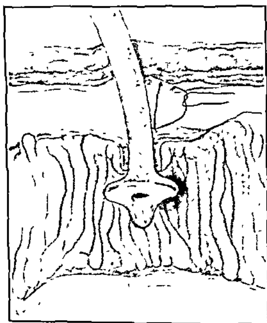


Fig 631.—The third stage of the Hendon enterostomy. The probe is quickly withdrawn and the purse-string suture is tied. Another purse-string suture is inserted and the ends of the suture are passed through parietal peritoneum in order to fix the bowel in position It is highly important not to transfix the catheter with sutures.

When there is an acute obstruction from an old lesion, such as well-organized adhesions, or from strangulation or mesenteric thrombosis, the cause of the obstruction should be determined and relieved, even though it may involve a somewhat

prolonged operation. The diagnosis of cancer of the colon can often be made by the symptoms, more accurately by a barium enema. In cancer of the colon, a different type of enterostomy may be indicated, if the distention persists. Here a complete cecostomy or colostomy is often the operation of choice, this being done to defunctionate completely the distal end of the bowel. This operation is described in Chapter 60, Operations on the Colon and Rectum.

In obstruction of the small bowel, however, this oblique type of enterostomy is often the best procedure. In the obstruction that occurs from a few days to a few weeks after an abdominal operation and probably results from lymphatic adhesions, an enterostomy in the small bowel, without extensive exploration of the site of the obstruction, is a very satisfactory treatment. This should be done only after intestinal intubation has failed to relieve the obstruction. This type of obstruction, which is due to lymphatic adhesions, will often clear up in a few weeks, and the bowel resumes its normal function.

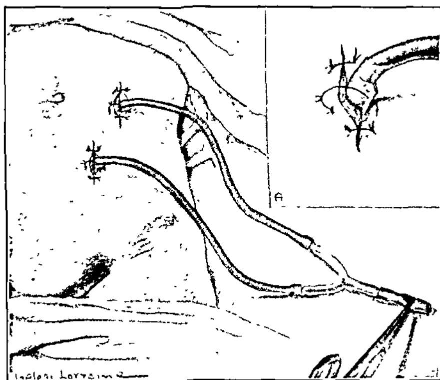



Fig 632.—When the obstruction is rather high and too much of the contents of the jejunum are lost, a second enterostomy can be done lower down, using either the oblique Witzel technic or the technic of Hendon. The contents from the upper small bowel are then shunted to the bowel below the obstruction by a Y-shaped tube.

In obstruction in the small intestine one of the chief indications is to correct the loss of fluids and salts as well as to relieve the pressure on the upper small intestine and the stomach. If the enterostomy is for feeding purposes, it should be high on the left side in the upper part of the jejunum When a duodenal fistula cannot be well controlled, a jejunostomy not only provides an avenue for feeding, but the discharge from the duodenal fistula may be collected and turned into the intestine through the jejunostomy.

In multiple obstructions two or more enterostomies may be made, or if the obstruction is high in the jejunum, a jejunostomy above the obstruction may be followed by an enterostomy below the obstruction, and in this way the contents of the

upper bowel are directed into the lower bowel (Fig. 632). We have practiced this procedure several times with much satisfaction. The tube from the upper jejunostomy is attached to one limb of a Y-shaped glass connection, the other limb of the Y being joined to an enterostomy below the obstruction. The stem of the Y is connected to a larger rubber tube, which is attached to a large glass syringe. At suitable intervals the material from the upper bowel is drawn into the syringe while pressure with the fingers is made on the enterostomy tube in the lower bowel. Then the procedure is reversed, the fingers compressing the tube to the upper enterostomy and the syringe forcing its contents into the tube in the lower enterostomy. This can be kept up with a pumplike action at sufficient intervals to relieve the obstruction in the upper bowel, and at the same time conserve all of the intestinal contents.

When jejunostomy is made for feeding, the intestine is small and collapsed and if a large rubber catheter is used for an oblique enterostomy it may produce too much occlusion of the intestinal lumen. In such cases the adoption of Coffey's principle which he established in transplanting the common bile duct or the ureter may well be utilized. The incision for a feeding jejunostomy is made in the upper left side of the abdomen above the level of the navel. The position of the transverse colon and omentum influence the incision to some extent. The outer portion of the rectus muscle is incised, splitting its fibers for 5 or 7.5 cm. The omentum may come into the wound; it is either pushed toward the midline, or incised and the jejunum approached through the incision in the omentum. When the jejunostomy is indicated for feeding, the small bowel may be so collapsed as to make it somewhat difficult to deliver. A portion of the jejunum is selected as near its origin as possible. The methods of identifying the small bowel as established by Monks are helpful (Figs. 633, 634, 635, 636, 637, and 638). The direction of the bowel should first be ascertained, preferably by running the finger along the mesentery while the loop of bowel a few centimeters long is held taut. If the abdominal wall is thick, a sponge-holding forceps is gently introduced to the root of the mesentery, either on the inner or the outer surface of the loop, and pushed away from the loop. It is rather important to determine the direction of the loop of bowel in making an enterostomy for feeding. When the loop of bowel is delivered and its direction is ascertained, it is caught with soft-bladed clamps, pressing on the loop to expel as much of its contents as possible before tightening the clamp. The surrounding tissues are packed off with moist gauze. Along the convex border of the bowel an incision about 6 or 7.5 cm. is carried down to the submucosa but *not through it.* The margins of the incision consisting of the peritoneum and the muscular coat are dissected back from the submucosa partly by a sliding stroke of the knife and partly by blunt dissection. A strip of submucosa about 1.25 cm. wide is thus exposed. This can readily be done in bowel that is not thinned by distention (Fig. 639). A purse-string suture of catgut or silk is placed around the distal end of the incision but is not tied. Usually a straight needle is preferable in placing the suture, but if exposure is difficult, a curved needle may be used.

The first loop of a knot is made in the purse-string suture while the portion of the thread opposite the knot is caught with mosquito forceps. The purse-string suture is lifted up by the mosquito forceps and by the ends of the incomplete knot. With a sharp-pointed knife, the bowel within the purse-string suture is punctured. Suction draws off the fecal contents, but when the bowel is collapsed, this may not be necessary, and the small amount of material from the bowel is sponged off with

gauze soaked in mercuric iodide solution. A soft rubber catheter, No. 16, with an additional perforation near the tip, is carried through the perforation within the grasp of the purse-string suture, while the perforation is being dilated with sharp-pointed hemostatic forceps. When the catheter has passed beyond the second perforation, the purse-string suture is tied, and an end of the suture transfixes the wall

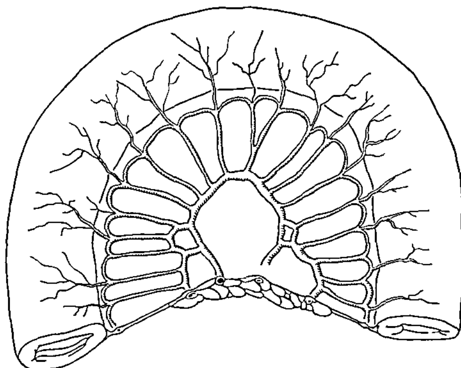


Fig 633.—A loop of intestine, the middle of which is exactly three feet from the end of the duodenum. The gut is of large size. The mesenteric loops are primary and the vasa recta are long and regular in distribution The translucent spaces (lunettes) are extensive. Below, the mesentery is streaked with fat The veins, which had a distribution similar to the arteries, are for simplicity omitted from this and from the subsequent drawings. (After Monks.)

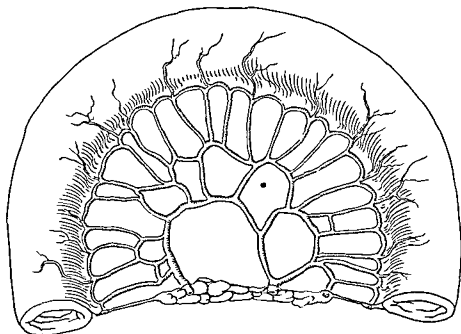


Fig 634.—A loop of intestine at six feet As compared with the preceding figure, the gut is somewhat smaller and the vascularity of the intestine and of the mesentery is less Secondary loops are a prominent feature The vasa recta are shorter The lunettes are also present but are not so large as in the preceding figure (After Monks )

of the catheter and is again tied. The suture is cut short. If the catheter is to be brought through the wound, which is the usual procedure in jejunostomy for feeding, it is connected with another tube. If, however, there is a long incision and the enterostomy is for obstruction, it would be better to bring the catheter through a stab wound in the abdominal wall before inserting it into the bowel. In this

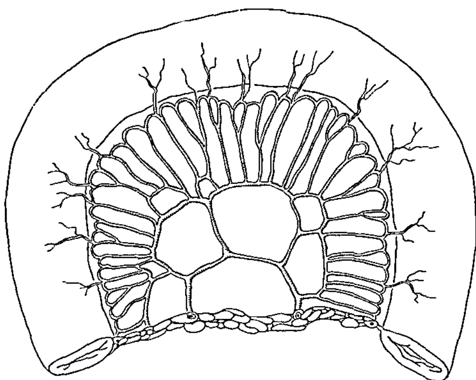


Fig. 635.—A loop of intestine at nine feet. The secondary loops are large, and the vasa recta are somewhat irregular and show branches. No lunettes are present, and the mesentery is streaked with fat and is, therefore, somewhat opaque. (After Monks.)

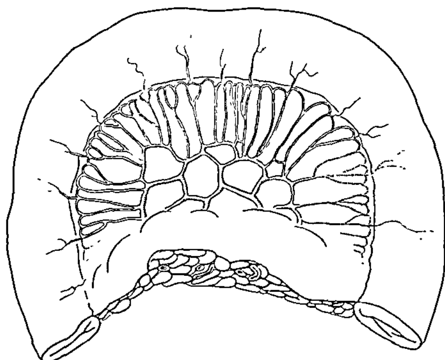


Fig. 636.—A loop of intestine at twelve feet. The vessels are smaller. The primary loops are lost in the fat, but secondary and even tertiary loops are visible. The vasa recta are shorter, more irregular, and branching. (After Monks.)

way the danger of infecting the abdominal wound by drawing the catheter through the stab wound after it has been inserted into the bowel is avoided. The catheter, being fixed in the intestine, is then attached to a tube, and the soft-bladed clamp is removed.

The catheter is placed upon the exposed submucosa, and a continuous suture of fine chromic catgut which catches the margins of the wound on each side of the

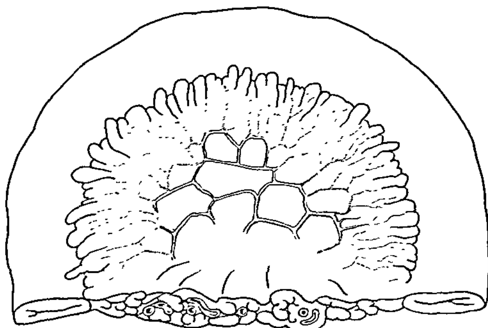


Fig. 637.—A loop of intestine at seventeen feet. The mesentery is opaque, and small tabs of fat begin to appear along the mesenteric border of the gut. The vessels are represented by a somewhat complicated network and are seen with difficulty in the thick fat of the mesentery. (After Monks.)

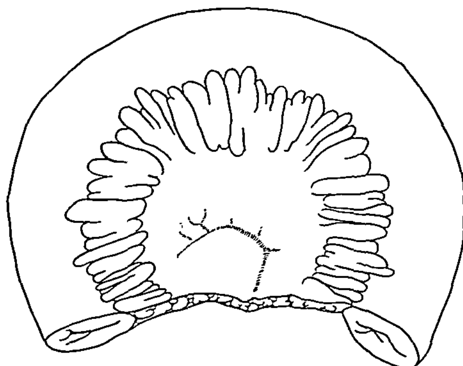


Fig. 638.—A loop of intestine at twenty feet. The gut appears to be thick and large. The mesentery is quite fat and opaque, and large and numerous fat tabs are present. The vessels, which are complicated, are seen with difficulty and are represented by mere grooves in the fat. (After Monks.)

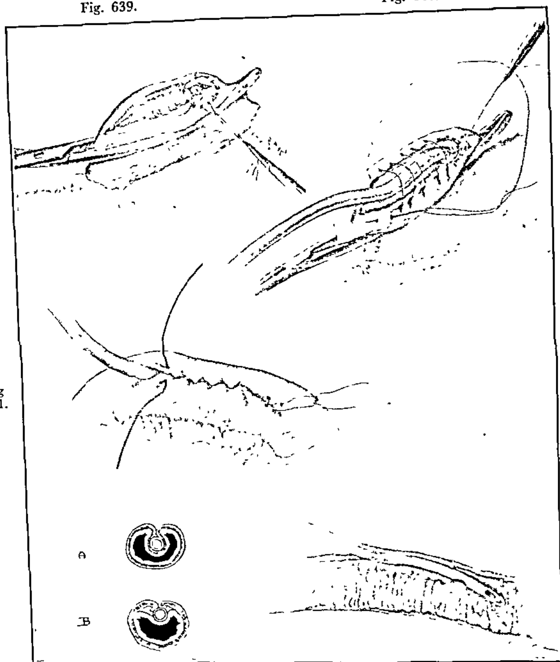



Fig. 639.—The first step of oblique jejunostomy by the Coffey principle. The bowel is clamped and the peritoneal and muscular coats are incised down to the submucosa. A purse-string suture is placed at one end of the wound and the mucosa is punctured.

Fig. 640.—A medium-sized soft rubber catheter with an additional perforation is inserted into the punctured wound of the mucosa The purse-string suture is tied, passed through the catheter, and again tied The catheter is held on the bed of the submucosa with a continuous suture.

Fig. 641.—The continuous suture is doubled back as a right angle suture and tied to its original knot A suture of fine catgut is inserted in the bowel wall just as the catheter emerges. The ends of this are to be passed through the parietal peritoneum Another suture should unite the bowel on the other side of the catheter to the parietal peritoneum.

Fig. 642.—Sectional view of the enterostomy according to the method of Coffey. Transverse section of the bowel according to, *A*, the Witzel technic and, *B*, the Coffey principle, demonstrating the large amount of lumen after the Coffey operation.

exposed submucosa fixes the catheter in position against the exposed submucosa. The catheter is not buried by this suture, which begins at the purse-string, but is merely held snugly in position (Fig. 640). This suture, after a backstitch to lock it, is doubled back as a continuous right angle suture and buries the catheter completely, approximating the wall of the intestine over the catheter, and making an oblique channel. The region of the wound in the bowel is mopped with moist gauze, and the bowel is replaced in the peritoneal cavity. An interrupted suture of fine chromic catgut is inserted where the catheter emerges from the bowel and is carried through the parietal peritoneum (Fig. 641). Another suture should fasten the bowel on the other side of the catheter to the parietal peritoneum. This fixes the bowel to the parietal peritoneum where it leaves the peritoneal cavity, and there is no need for further protection with omentum.

The abdominal incision is closed by first uniting the parietal peritoneum and the posterior sheath of the rectus muscle with fine chromic catgut. A few stout retention sutures are placed through all of the abdominal wall except the peritoneum, but are left untied. Chromic catgut sutures close the anterior sheath of the rectus muscle, and the skin is sutured with fine silk, and the heavy sutures are tied If the catheter is brought out through the original wound, it should be placed either at the upper or lower angle and a piece of iodoform gauze carried down to the peritoneum along the catheter. Adhesive plaster is wrapped around the catheter as it emerges from the skin, and a stout silk suture is passed through the adhesive and the skin.

The purse-string suture of silk which fastens the catheter in the bowel will not hold indefinitely; usually it works loose in one or two weeks, and it is best to reinforce this suture by fastening the catheter to the skin as has just been described. Should the purse-string suture hold longer than is desirable, elastic traction on the catheter will readily loosen it. This may be accomplished by attaching a small rubber band to the catheter and fixing it with adhesive plaster at some point on the body that will provide light traction on the catheter.

If obstruction demands an enterostomy, the bowel is already much dilated and the abdominal incision should be made in a region that will be approximately near the obstruction. If the abdominal distention is universal, and symmetrical, the incision should be made in the lower right abdomen, using the principle of a muscle-splitting McBurney incision. If the distention appears to be chiefly on the left side, a muscle-splitting incision in the left iliac fossa will be the best approach.

Constant drainage of the stomach by a Jutte tube, as advocated first by Matas, and later by many other surgeons, particularly Wangensteen, Orr, and Ochsner, or intubation of the small bowel with a Miller-Abbott or similar tube is a very important procedure in obstruction of the small bowel and will often avoid the necessity for an enterostomy The tube is inserted through the nostril and suction is made on it either at frequent intervals with a syringe or continuously by a syphon apparatus. If, however, the obstruction is not materially improved within a few hours, laparotomy should not be delayed Under any condition, continuous intravenous injection, preferably of 5 per cent dextrose in Ringer's solution, is administered in order to prevent dehydration and to replace the lost electrolytes.

In high intestinal obstruction, when the chlorides in the blood are low and the urea is high, the value of an additional amount of salt has been very forcibly

pointed out by Haden and Orr. If the salts in the blood are quite low, a sufficient amount of 5 per cent salt solution may be added to the Ringer's solution while it is flowing to counteract the deficit in chlorides; usually 100 c.c. of this salt solution is sufficient in addition to the constant flow of the 5 per cent dextrose in Ringer's solution. However, the amount should be guided to a large extent by the blood chlorides, and, of course, by the clinical condition of the patient. It is equally important to keep a careful check on the potassium level in the blood. It is felt that if Ringer's solution is used as the routine intravenous fluid instead of saline, there would be fewer cases of potassium deficiency. In cases of proved potassium deficiency, Ringer's solution by itself will not restore the level to normal and the addition of a more concentrated potassium solution to the intravenous fluids is a necessity.

In obstruction with a dilated and probably thin bowel there is usually no occasion for using the principle of Coffey and exposing the submucosa, though if the bowel is not too thin this procedure may be adopted. A purse-string suture is inserted without exposing the submucosa and a catheter is inserted through a perforation in the manner just described The catheter is buried on the intact intestinal wall with two rows of continuous sutures of fine chromic catgut. Reference to the diagram (Fig. 642, *A* and *B*) will show the advantages of using the Coffey principle wherever possible. Not only is there a smaller infringement upon the lumen of the bowel, but the channel is probably less rigid when the submucosa constitutes most of the wall of the channel than if the whole channel were lined with peritoneum. The peritoneum readily throws out exudate, and the oblique opening, for a while at least, becomes a rather rigid tube. The submucosa and the mucosa tend to be more flexible and act somewhat like a valve. Consequently, when the catheter is removed there is less likelihood of a fecal fistula resulting. In more than half of our cases done with the Coffey principle of exposing the submucosa, there has been no leakage of fecal matter after removing the catheter. With a greatly dilated and thin bowel, as in obstruction where there is urgent need for completing the operative procedure as quickly as possible, this slight advantage may be disregarded and a typical Witzel operation performed.

Formerly a nonabsorbable material was used for infolding the catheter on the intestinal wall Not infrequently, however, particularly after obstruction, there is some infection in the abdominal wall and a sinus may result which does not heal until the nonabsorbable suture is removed. Usually the suture works into the intestinal lumen, but in the presence of infection along the drainage tract it may tend to be extruded externally. Fine chromic catgut, especially when two rows are placed, is sufficiently safe and avoids this complication.

If it seems probable that there will be infection in the abdominal wall, as when an operation for obstruction is done in the presence of peritonitis, a muscle-splitting incision is particularly advisable, and after inserting, but not tying, a few through-and-through retention sutures and closing the parietal peritoneum, it would be best not to place any further sutures in the abdominal wall but to pack the wound lightly with petrolatum or iodoform gauze. With a McBurney incision, no sutures except in the parietal peritoneum need be placed, and the whole wound may be packed lightly with gauze. In the McBurney type of muscle-splitting incision this method has been found particularly satisfactory in the presence of sepsis. At the same time the closure of the peritoneum up to the tube prevents extrusion of the

bowel, and the natural action of the muscles in the muscle-splitting incision reinforces the peritoneum, so that eventually a hernia rarely results.

If the enterostomy is for obstruction, a larger catheter is used than if the enterostomy is intended for feeding. A No. 20 or 22 catheter in obstruction is an adequate size and is irrigated every two or three hours with 30 to 40 c.c. of warm salt solution. A larger irrigation is not necessary. After two or three days, when the immediate effects of the obstruction seem to have been relieved, the catheter is clamped for two hours and left open for one hour. In this way the excessive loss of liquid feces is limited. If pain reappears when the catheter is clamped, this procedure is abandoned.

If the enterostomy is for feeding, of course the catheter is clamped between the intervals of feeding

If one enterostomy does not relieve the obstruction, there should be no hesitation in doing a second one, and the fecal current may be detoured through a Y type of apparatus, as has already been described.

The Brown enterostomy is for complete physiologic rest of the colon and has occasional indication, particularly if the colon is extensively diseased and resection of a large portion or all of it is contemplated, as in certain types of ulcerating colitis. If the transverse or left colon is to be resected, a complete enterostomy in the cecum and ascending colon, which is described in another chapter, would be more satisfactory.

In the Brown operation the ileum is brought up and divided between two clamps about 10 cm from its end. The lower end is closed by a suture, preferably of the basting stitch type, reinforced by another suture, and is fastened lightly to the parietal peritoneum. Several centimeters of the mesentery are incised in order to provide sufficient mobility of the two ends. The blood vessels are secured and the upper end, still clamped, is brought into the wound and sutured to the parietal peritoneum with a few interrupted sutures of fine catgut. A purse-string suture of silk is inserted around the margins of the upper stump. The bowel is well packed around with moist gauze and when the clamp is removed a large catheter is inserted in the upper end and the purse-string suture is quickly tied (Fig. 643). An end of the purse-string suture is passed through the catheter and is again tied. The bowel is loosely attached to the abdominal wall and packed around with petrolatum or iodoform gauze. The stools, which are liquid at first, soon take on a semisolid character.

The catheter may work itself loose in a week or two, but during this time the adhesions around the enterostomy will prevent the danger of peritonitis. A larger tube may then be inserted and connected by another tube to a bottle about the bed, which will make the patient more comfortable.

When a permanent ileostomy is being made, care must be taken to see that several centimeters of the bowel are beyond the skin. It is far better to have too much than too little of the bowel protruding. There is always contraction of the bowel during the first few weeks and it is essential that the mucosa of the bowel is well above the skin. Because the bowel content of an ileostomy is and always will be liquid, some type of ileostomy bag is a necessity and the stoma of the ileum must be long enough to deliver the bowel content into the bag without spillage or seepage along the skin. With the modern type of ileostomy bag and its elastic cement, ileostomies are no longer a constant source of irritation and embarrassment to the patient.

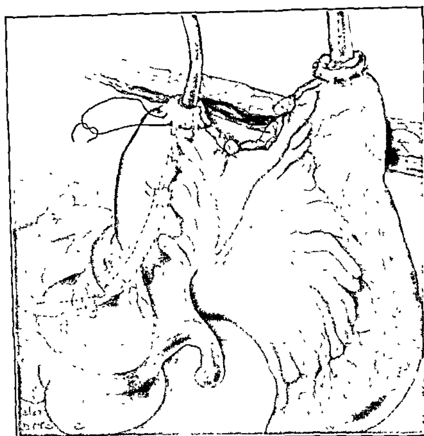


Fig 643.—The John Young Brown enterostomy. A medium-sized soft rubber catheter has been introduced into the distal end, fixed with a purse-string suture, and a second purse-string suture is placed. A larger tube is applied in the oral end of the bowel where no effort is made to invert the peritoneum.

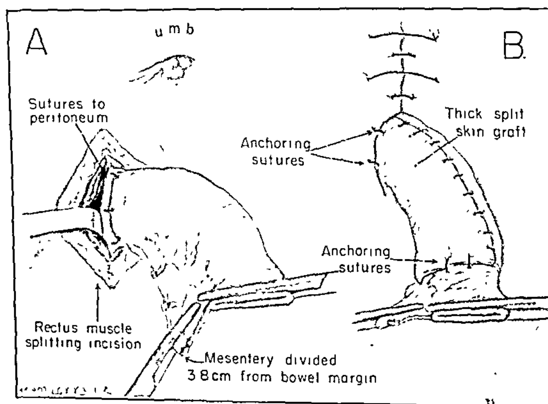



Fig 644.—Dragstedt's method of covering an ileostomy with a skin graft. *A*, The ileostomy has been completed but not covered with the skin graft. *B*, The split graft has been sutured in place.

Dragstedt advocates skin grafting the protruding portion of the ileostomy wi thin Thiersch skin grafts. This can be done at the time of the original ileoston and seems to be worth while, as it gives a more stable and comfortable wou (Fig. 644).

The distal end of the ileum may be brought up to the abdominal wall, as a ready described, or may be closed securely and dropped back into the peritone cavity, as advocated by Stone.

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# CHAPTER 57

# OPERATIONS ON THE SMALL INTESTINES (CONTINUED)

Guy W. Horsley

## RESECTION AND UNION OF THE SMALL INTESTINE

Union after resection of the small bowel may be of three kinds: end-to-end, lateral, or end-to-side anastomosis. The end-to-end and the lateral are the most generally used methods, except when the ileum is united to the colon. Here the end of the ileum is often implanted into the side of the transverse colon.

In resection of the small bowel alone, the condition of the bowel and the portion of the intestine involved determine the type of operation In the upper small intestine the bacterial content is low, peristalsis is active, and the bowel is quite sensitive to obstruction, so that an ample caliber must be maintained. In the lower ileum, particularly if the patient is fat, the lumen of the bowel is small and the presence of the fat interferes with end-to-end union not only mechanically but the larger triangular space at the mesenteric border which is caused by the fat makes infection with the intestinal contents more likely to occur. Under these conditions a lateral anastomosis may be preferable.

In the upper small bowel an end-to-end union is an excellent procedure. Coprostasis is maintained in the segment of the bowel to be removed, preferably with small rubber bands. The mesentery to the affected loop is doubly clamped and divided in sections, which later are transfixed and tied with catgut. The ends of the ligatures are left long and clamped. If the removal of a long segment of the bowel is necessary, clamping every third ligature instead of all the ligatures will be more satisfactory. The ligatures that are not clamped are cut short. As the incision in the mesentery approaches the bowel, the triangular space where the mesentery divides to encompass the bowel is encountered (Fig. 645, *A*). This triangular space has no peritoneal covering, and infection and leakage in this region must be avoided. It is clamped and permanently closed by transfixing and tying it with a suture which may be of catgut or silk. This suture is clamped in such a way as to distinguish it from the ligatures on the mesentery. The nutrition to the bowel at the point of division is highly important, and unless the operation is for malignancy, the mesentery should be divided fairly close to the bowel. In some cases, however, an inflammatory process may demand a wider excision of the mesentery.

Before ligating the triangular space, the bleeding from it should be noted. If it is not free, an incision along the junction of the mesentery and the bowel is made until a spurting vessel is encountered. The triangular space is then ligated. Two clamps are placed on the intestine at the proposed line of division in a somewhat oblique direction, going from the mesenteric border outward. The bowel is divided between the clamps from the mesenteric border outward with either a knife or an

Dragstedt advocates skin grafting the protruding portion of the ileostomy with thin Thiersch skin grafts. This can be done at the time of the original ileostomy and seems to be worth while, as it gives a more stable and comfortable wound (Fig. 644).

The distal end of the ileum may be brought up to the abdominal wall, as already described, or may be closed securely and dropped back into the peritoneal cavity, as advocated by Stone.

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## CHAPTER 57

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In the upper small bowel an end-to-end union is an excellent procedure. Coprostasis is maintained in the segment of the bowel to be removed, preferably with small rubber bands. The mesentery to the affected loop is doubly clamped and divided in sections, which later are transfixed and tied with catgut. The ends of the ligatures are left long and clamped. If the removal of a long segment of the bowel is necessary, clamping every third ligature instead of all the ligatures will be more satisfactory. The ligatures that are not clamped are cut short. As the incision in the mesentery approaches the bowel, the triangular space where the mesentery divides to encompass the bowel is encountered (Fig. 645, *A*). This triangular space has no peritoneal covering, and infection and leakage in this region must be avoided It is clamped and permanently closed by transfixing and tying it with a suture which may be of catgut or silk. This suture is clamped in such a way as to distinguish it from the ligatures on the mesentery. The nutrition to the bowel at the point of division is highly important, and unless the operation is for malignancy, the mesentery should be divided fairly close to the bowel. In some cases, however, an inflammatory process may demand a wider excision of the mesentery.

Before ligating the triangular space, the bleeding from it should be noted. If it is not free, an incision along the junction of the mesentery and the bowel is made until a spurting vessel is encountered. The triangular space is then ligated. Two clamps are placed on the intestine at the proposed line of division in a somewhat oblique direction, going from the mesenteric border outward. The bowel is divided between the clamps from the mesenteric border outward with either a knife or an

electric cautery. The nutrition of the bowel is better assured by placing the clamps obliquely, and a larger lumen is also provided. One stump of the bowel is surrounded by gauze moistened with salt solution, and the clamp is removed. The margin of the stump which is compressed by the clamp is pulled open with forceps and caught in several places with hemostatic forceps. The bowel contents are cleaned out with strips of gauze soaked in mercuric iodide solution. This cleansing must be thorough, though gentle, and extends to the portion of the bowel that is occluded by the rubber bands. The stump is then loosely packed with a strip of

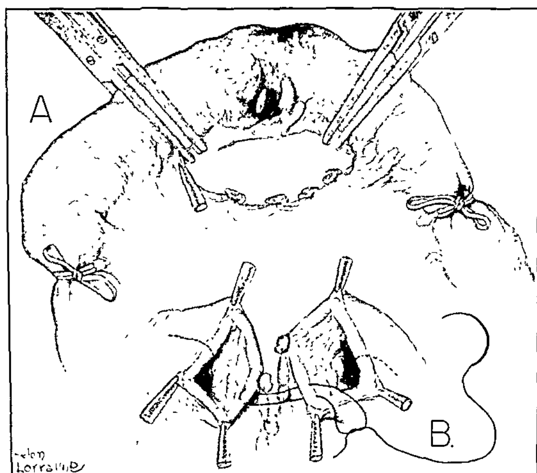



Fig 645 —*A*, The loop containing the lesion has been isolated with small rubber bands The mesentery is clamped in sections and tied The loop of bowel to be removed is clamped obliquely *B*, The ends of bowel have been thoroughly cleaned The triangular area has been clamped and tied The first knot of the continuous mattress suture is being tied. The dots show line of incision to enlarge area of anastomosis

moist gauze. The other stump is treated in a similar manner. The ends of the bowel are approximated. The suture is of silk and is applied with a small, curved needle without a cutting edge. The suture is inserted from the mucous membrane on the right-hand stump about 1 25 or 2 cm. from the mesenteric border and about 0.75 cm. from the margin of the stump It is then carried to the left-hand stump, going from without inward just to the right of the mesenteric border The needle is returned in a reverse direction from within outward on the left stump and from without inward on the right stump, appearing in the right-hand stump at a point near its original insertion (Fig 645, *B*). It is then tied snugly as the ends of the bowel are approximated, and the short end is clamped. This makes a mattress suture and in-

sures that the triangular spaces of the mesentery of the two stumps are side-by-side and not opposite each other. In this way, each triangular space is approximated by a peritoneal coat on the opposite side, and the danger of apposing two raw surfaces, neither of which is covered with peritoneum, is avoided. The suture is passed back and forth as a mattress suture for several stitches. The suture is drawn snugly and locked by taking a backstitch, passing the needle just behind the point of its last insertion. The mesenteric border of the bowel is thus held in firm apposition with a distinct flange protruding into the lumen of the bowel (Fig. 645, *C*).

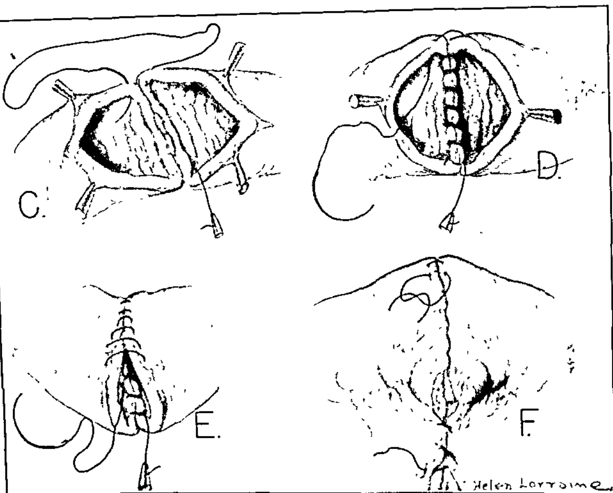



Fig. 645 (continued). *C*, The continuous mattress suture has been completed across the mesenteric border of the bowel. *D*, The continuous mattress suture is passed through the bowel and an extra stitch is taken to lock it. The mesenteric third of the bowel is sutured over with a continuous suture of catgut or silk in order to approximate the mucosa in this region more accurately. *E*, The mattress suture has been continued as an over-and-over stitch and will be tied to its original end. *F*, The first row of sutures has been placed and an additional interrupted mattress suture is shown. The peritoneum of the mesentery is also sutured.

In this region there is no danger of applying this suture too tightly, as there would be with an external suture, because the tissue within its grasp becomes necrotic just as would the tissue within the firm pressure of a Murphy button. The thread is applied from within the bowel. Care must be taken in suturing the mesenteric side of the bowel to prevent the eversion of the mucous membrane, for, as the bowel is cut obliquely, the mucosa comes to a point at the mesenteric border and may insinuate itself between the sutures, which would make a drainage track for the bowel contents. It is important to visualize the margins of the mucous membrane on each side as the suture is being placed.

When one-third of the circumference of the bowel has been sutured, the mucosa of the sutured portion is more accurately approximated with interrupted sutures or a continuous suture of fine silk (Fig. 645, *D*). This additional suture protects the mesenteric border from the infiltration of the fecal contents which necessarily come in contact with the anastomosis as soon as the rubber bands are removed. Particularly if there is much fat in the mesentery, the margins of the stump along the mesenteric border will form a flange and possibly some slight pockets which may catch fecal matter. This second row of sutures does not decrease the lumen of the bowel, but may even enlarge it by compressing the flange. There is no occasion to continue this suture over more than the mesenteric third of the bowel. After it has been tied, the needle in the original suture is thrust through the bowel from the mucosa to the peritoneum. The thread is drawn snugly and locked by a backstitch.

Attention has been called to the necessity of a patent lumen in the upper small intestine where obstruction may easily supervene from the turning in of a large diaphragm. Occasionally, when the lumen appears sufficient immediately after the operation, the subsequent swelling may produce obstruction. If the lumen of the anastomosis does not appear to be adequate, short longitudinal incisions are made in the bowel wall opposite the mesentery and then the suturing is carried out as before (Fig. 645, *B*). These two small incisions give an increased diameter to the lumen. In order to be certain to avoid obstruction, the anastomosis may be made over a rubber tube. A rubber drainage tube about 10 cm. long and about 0.5 cm. in diameter is selected, and an additional perforation is cut near each end of the tube. In one end, preferably the one that will be in the distal part of the bowel, a long loop of silk thread is placed with a needle and tied in several knots. This drainage tube is put in the bowel at this stage of the operation, and a silk suture is inserted through the drainage tube at about its middle and catches the margins of the sutured bowel. In this manner the tube is fixed in position so that a patent lumen at the point of anastomosis is insured. The suture probably holds no longer than one or two weeks. The silk at the end of the tube is caught in the fecal current, and gentle traction is thus made on the tube by peristalsis; this insures its expulsion.

The suture is then inserted as a continuous mattress suture or right angle suture, with an occasional backstitch, and penetrates into the lumen of the bowel with each bite of the needle. Only enough of the margin of the bowel is turned in to assure approximation of the peritoneum (Fig 646). The suture is carried to the region of the short end of the knot of this suture, when another backstitch is taken, and the suture is carried to the right-hand side one stitch beyond the point at which the short end emerges. It is then reversed, taking one stitch on the left-hand side. The needle is removed from the thread and the suture is tied firmly to the short end of the first knot of this row of sutures. It should be tied down in the axis of the suture line, so that the original short end which is on the mucosa of the right-hand stump of the bowel draws the final knot within the lumen of the bowel After the knot is tied several times, it is cut short and the knot usually will disappear into the lumen of the bowel. A simple over-and-over suture with an occasional backstitch is also most satisfactory and often easier to use (Fig. 645, *D* and *E*) This type of stitch is more hemostatic than the mattress stitch. If for any

reason the bowel wall is thick, the knot may remain to some extent on the surface. Under any condition, it is best to put an interrupted mattress suture in this region. The surface of the bowel is mopped with moist gauze, and the anastomosis is reinforced with additional interrupted mattress sutures of chromic catgut (Fig. 645, *F*) at any weak spot. One or two extra sutures are inserted on the convex border to protect from any strain from peristalsis.

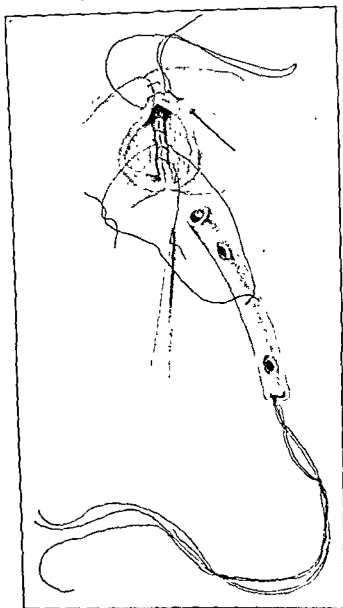


Fig. 646.—Method of resection of the small intestine, with the insertion of a rubber tube to maintain the lumen during healing

*Without* the insertion of the drainage tube that has been described, or making the short longitudinal incision on the antimesenteric border of both ends of the bowel, the placing of additional sutures for reinforcement around the suture line may be fraught with the danger of turning in too much diaphragm. With the introduction of the tube, however, this danger no longer exists, and while an ample lumen should be provided by the method of suturing, the edema in the ends of the bowel may cause temporary obstruction. This edema begins to subside at the end of four or five days before the tube leaves the site of the anastomosis.

The interrupted mattress sutures placed over the terminal suture and at other places should be tied merely tightly enough to approximate the tissues. If tied too tightly, necrosis and leakage may result.

If the bowel ends are of unequal caliber, the smaller caliber can be increased by a longer longitudinal incision on the convex border of the lower end.

In the lower ileum the mesentery is fat and the lumen of the bowel is small, and here an end-to-end union may not be advisable. In such cases the fat in the mesentery forms a considerable bulk and spreads onto the side of the bowel, which makes the suturing along the mesenteric border difficult. If much fat is included in the suture, the fat will break down and leakage may result; yet if the bowel is not rather firmly approximated in this mesenteric portion, leakage will be inevitable. If there is but little fat, an end-to-end suture may be indicated even in the lower ileum.

A lateral anastomosis is safer than an end-to-end union in the presence of extensive fat. The loop of bowel to be resected is removed as in the end-to-end union. Over each stump a basting stitch of silk is placed before the clamp is removed. It is drawn snugly by traction on each end of the suture in the axis of the clamp while the clamp is gently opened and removed. Smearing the jaws of the clamp with petroleum jelly before the clamp is applied may render the removal of the clamp easier. This procedure inverts the margin of the bowel, and one end of the basting stitch is used as a returning suture, either an overhand stitch or a continuous mattress suture, and is tied to the original end of the basting stitch. If the fat is not very prominent, the two ends of the basting stitch may be tied together instead of returning one end. This is reinforced by a purse-string suture or by another row of sutures. At least two, and preferably three, rows of sutures are placed on each stump. The ends of the bowel are placed side-by-side, pointing in opposite directions. Each end is sutured to the bowel by its side with catgut or silk, and these sutures are used as tractor sutures. The ends should overlap for about 6 25 or 7.5 cm. These two parallel portions of bowel are united with a continuous overhand or mattress stitch of catgut or silk. A backstitch is made, and the suture is temporarily discontinued The bowel is incised for the length of the suture line about 0 6 cm. from it; each end of the bowel is thoroughly cleansed with strips of moist gauze as described in the end-to-end union. The incision, particularly on the oral end of the bowel, should go well into the end of the stump; otherwise a blind pocket will result in which fecal contents will accumulate and may eventually cause a perforation. In the distal stump this is not so important, but no culdesac should be left in either stump The incision should be carried well to the inverted tissue at each end. Much of this inverted tissue will eventually become necrotic and will be extruded, and, if the incision is not carried well toward the end, a pouch may result from the disappearance of much of this inverted tissue. A continuous lockstitch of silk unites the posterior margin of the incision in one side of the bowel to the posterior margin of the incision in the other (Fig. 647) When the posterior margins have been approximated, the suture is carried forward uniting the anterior margins of the wound, as has been described in lateral anastomosis for short-circuiting.

The first line of sutures is resumed, carrying it forward as a right angle continuous suture with an occasional backstitch, and is tied to its original end Each stump is lightly sutured to the adjacent portion of the bowel by a few interrupted sutures which should not penetrate the tissues very deeply

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Murphy and Cannon have shown that division of the circular muscle fibers of the bowel results in stasis of the fecal current at the stoma of a lateral anastomosis, whereas when the circular fibers are unimpaired as in end-to-end union, the fecal current proceeds normally. This objection, however, is not an important one, because after a lateral anastomosis the bowel tends to readjust itself, making the opening almost in the axis of the bowel. Stagnation only exists until the fecal contents from above expel the material that has stagnated within the anastomosis. While this objection cannot be entirely disregarded, it is not very serious and the safety of the suturing is the prime consideration.

End-to-side anastomosis is rarely used in the small intestine alone but is chiefly indicated when the ileum is to be united to the colon. In excision of the right colon, end-to-side union of the ileum to the undersurface of the transverse colon is an excellent procedure. It is described in the chapter on operations on the colon.

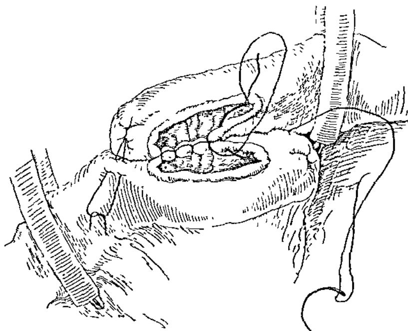


Fig. 647 —Lateral anastomosis. The ends of the bowel are closed with purse-string sutures and the openings are made close to the invaginated ends. The suturing is done as in gastroenterostomy. After the anastomosis has been completed, an additional suture between the end of the bowel and the wall of the opposing bowel is placed to avoid tension. Rubber bands may be used for coprostasis instead of soft-bladed clamps.

There are many technics for resection of the bowel. They were quite numerous in the earlier development of this operation, but the more complicated procedures have been abandoned. The Murphy button is rarely employed. While it produces an excellent scar because of the uniform narrow but firm approximation around the margin of the bowel, the pressure of the body of the Murphy button within the bowel may cause ulceration or even actual necrosis and leakage. If the button is of steel, it frequently weighs down the bowel as an anchor and may produce obstruction by kinking. After it has passed from the site of operation, the button sometimes lodges in the intestine about the ileocecal valve and causes obstruction there.

The so-called aseptic method of suturing the small bowel, as advocated by Kerr and Parker, often results in turning in too much diaphragm. This is particularly dangerous in the upper small intestine. In the jejunum there are compara-

tively few bacteria, and there is no reason why the lumen of the bowel should not be opened and carefully sutured, with ordinary regard for preventing infection. When a basting stitch is placed over a clamp, the margins of the wound are turned in as the basting stitch is tightened while the clamp is withdrawn. The two stumps of the bowel, each of which is infolded with a basting stitch, are sutured together, and then the basting stitches are removed. The adherent margins of each stump are separated by introducing the finger on one side of the anastomosis and the thumb on the other and approximating them.

It is readily seen that such a procedure must turn in a large diaphragm and that an accurate approximation of the margins of the wound from within is impossible by this technic. The large diaphragm or flange that is inverted tends to form pockets and irregular spaces where fecal matter may accumulate.

In an end-to-side union of the ileum to the colon, some form of aseptic technic may be advisable, because the conditions here are different from those that obtain in the end-to-end union of the small bowel. The diaphragm protrudes toward the large cavity of the colon, and as the colon with its fecal matter is very septic, every precaution should be made to avoid infection.

## DRAINAGE

Drainage should not be in contact with any sutured wound of the bowel. If there is peritonitis, as after perforation, and drainage seems necessary, the wound in the intestine is sutured, and then omentum or peritoneum-covered fat is brought over the intestinal wound. Drainage can then be instituted. A rubber tube or particularly a cigarette drain in contact with a sutured intestinal wound will, in a large proportion of the cases, result in a fecal fistula. The drains tend to attract lymph away from the sutured wound, and lymph is an important element in the repair of the intestine.

If a drain is placed in contact with a sutured intestinal wound, and a fecal fistula results, the drain has done actual harm because there would probably have been no fecal fistula without the drain

CHAPTER 58

# APPENDECTOMY

## ABDOMINAL INCISION; TREATMENT OF THE STUMP; APPENDICEAL ABSCESS AND PERITONITIS

Guy W. Horsley

For appendicitis, as for any lesion, the simplest operation that is efficient should be the one adopted. The McBurney incision is very satisfactory, especially in acute appendicitis. This incision is illustrated in some detail (Figs. 648, 649, 650, 651, 652, 653, and 654). In the majority of cases the appendiceal stump is treated simply without being buried, according to the general technic employed by the early operators for appendicitis. If this is impossible because of the diseased condition of its base, the appendix is excised flush with the cecum and the cecal wound is closed as though it were a stab wound, using either a single purse-string suture after controlling the bleeding, or else suturing the margins of the wound with a continuous suture of chromic catgut and burying this with a second row of right angle sutures of fine chromic catgut. In suturing wounds of the intestine, if the bleeding is controlled, one row of sutures is all that is necessary. If, however, there is doubt about controlling the bleeding, as where the bowel is clamped in such a manner as to cut off the circulation, or in the large bowel, where the surface is irregular and the intraintestinal pressure is considerable, two rows of sutures should be employed. As wounds of the cecum belong to this latter class, two rows of sutures after complete excision of the appendix are advisable. Such indications, however, do not often arise, for usually a sufficient amount of the appendix can be left to heal as a stump. The technic for appendectomy that is satisfactory for either chronic appendicitis or for the great majority of cases of acute appendicitis is as follows:

The appendix is, if possible, delivered into the wound. It is clamped about 0.8 cm. from its base, and two chromic catgut ligatures are carried through the mesoappendix close to the base of the appendix. The base is tied flush with the cecum with one of the ligatures, three knots being tied and the ends clamped. The mesentery of the appendix is tied with the other ligature (Fig. 655). If the mesentery is fat, the proposed site of ligation is first clamped with a pedicle forceps. In fat patients the mesoappendix sometimes tears and retracts when clamped. The clamping should not be too near the root of the mesentery so the fat-retracted mesoappendix can be readily caught if such an accident occurs. When there is but little fat, there is no occasion for clamping. The mesoappendix is severed with scissors, with a sufficient margin left beyond the ligature to prevent it from slipping. The ends of this ligature are tied snugly around the base of the appendix over the first

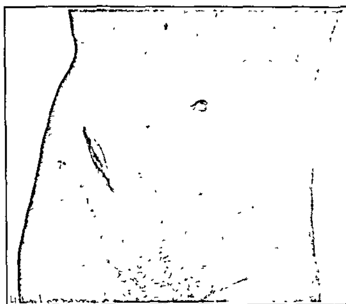


Fig. 648.—The skin incision for the McBurney muscle-splitting operation.

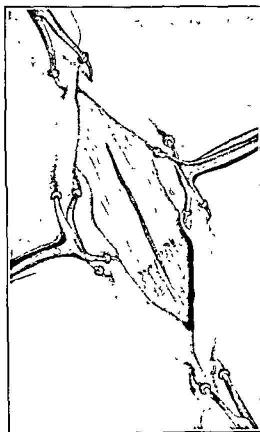


Fig. 649

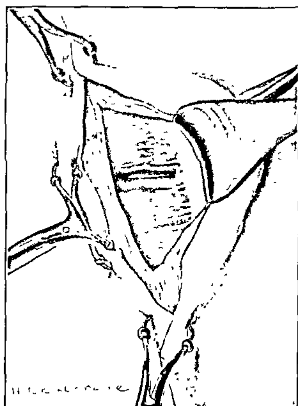


Fig. 650.

Fig 649—McBurney incision, showing the division of the aponeurosis of the external oblique and the protection of the margins of the skin and subcutaneous fascia by the method of folding over the towels and clamping them over the margins of the skin incision.

Fig 650—The aponeurosis of the external oblique has been divided and retracted, and an incision is made through the internal oblique and transversalis muscles

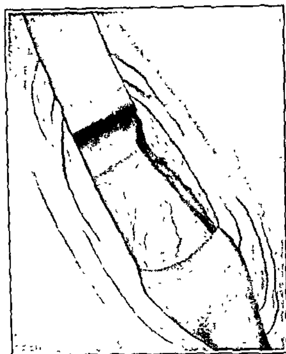


Fig. 651.

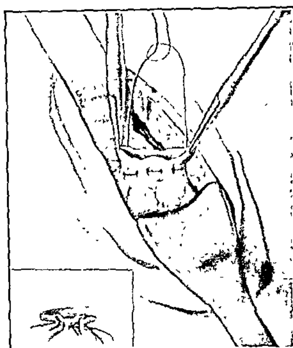


Fig. 652.

Fig. 651.—The fibers of the internal oblique and transversalis are held apart with retractors The peritoneum is shown in the wound.

Fig. 652—*The peritoneum* is closed with a purse-string suture or a continuous mattress suture which everts the edges of the cut peritoneum and brings broad peritoneal surfaces in contact. Inset shows the suture in the peritoneum after it has been tied.

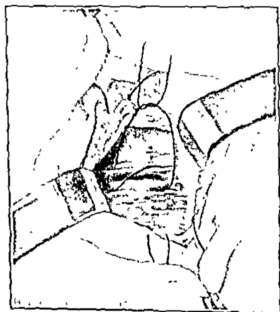


Fig. 653.

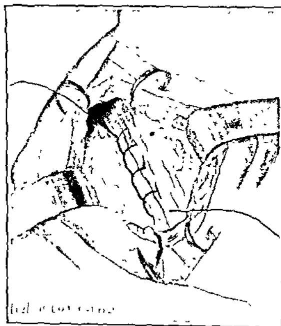


Fig. 654.

Fig. 653.—The fibers of the *internal oblique and transversalis muscles* are approximated by a suture of plain catgut which is loosely tied

Fig 654—The aponeurosis of the *external oblique* is brought together with a continuous lockstitch of plain catgut.

ligature and are cut short. This prevents retraction of the stump of the mesoappendix, which sometimes occurs and which may result in the tearing of small veins and oozing. The base of the appendix is surrounded with moist gauze and is severed with a knife or electric cautery close to the clamp and about 0 5 cm. beyond the ligature (Fig. 656). A dry sponge is placed by the stump of the appendix and the mucosa of the stump is disinfected with carbolic on a probe and is curetted away onto the gauze sponge with a small sharp curette the end of which has been dipped in pure carbolic (Fig. 657). The point of a scalpel will also serve for this. A drop of pure carbolic on the end of a probe is again rubbed into the stump of the appendix, and the gauze sponge onto which the eschar and mucosa were curetted is removed The excess of carbolic is mopped up with a dry gauze sponge.



Fig 655.—The base of the appendix and the mesoappendix are being ligated. The ends of the ligature on the mesoappendix are tied around the base of the appendix The base of the appendix should not be clamped before it is ligated, for this crushes an unnecessary amount of tissue The ligature only injures tissue within its grasp.



Fig 656 —The mesoappendix is divided.

The ends of the ligature on the stump of the appendix are left long and are threaded in needles and passed through the adjacent peritoneum-covered fat and tied Sometimes this fat is found at the ileocecal fold. Sometimes it is a tag from the cecum. Occasionally it may be a redundant mesoappendix (Fig. 658). Fat that will easily come over should be chosen and the ligature should be tied snugly (Fig. 659). This covers the stump of the appendix and promotes adhesions of the peritoneum-covered fat over the site of the stump of the appendix so that, even if

the mucosa did not heal satisfactorily, these adhesions should protect the peritoneal cavity from infection until the wall of the cecum is sufficiently repaired.

The wound is made and closed as described in the chapter on abdominal incisions and as shown in Figs. 648 through 654.

Where the appendix cannot be delivered into the wound, the technic is altered to suit the condition. The appendix is first ligated, clamped, and severed at its base; the stump is treated as has been described, and the end that is clamped in the forceps is disinfected. The mesoappendix is then clamped from the base outward by a

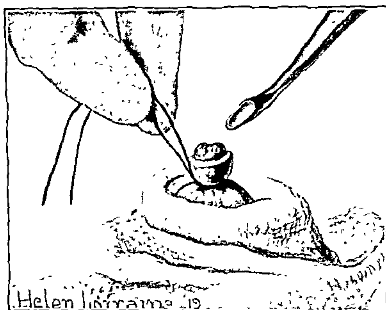



Fig 657.—After carbolic has been applied, the eschar and the mucosa in the stump are curetted. Carbolic is then applied again.

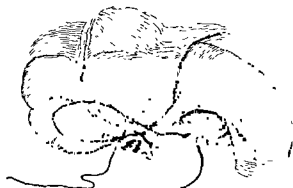


Fig. 658.



Fig. 659.

Fig. 658.—The ends of the ligature on the stump of the appendix are left long and are threaded in needles and passed through adjacent peritoneum-covered fat and tied.

Fig. 659.—The ligatures are tied snugly, covering the stump of the appendix.

series of forceps and is severed as each forceps is applied (Fig. 660). The vessels in the mesentery are controlled by sutures of catgut. The difference between an operation in which the stump of the appendix has been treated as described and in which it has been buried is well shown by the accompanying cuts (Figs. 661, 662, 663, and 664). A false analogy is often responsible for burying the stump of the appendix. It has been assumed that there should be no raw surface left in the peri-

toneal cavity whenever it can be prevented. This, as a rule, is a good doctrine, but there are exceptions. Because the stump of a broad ligament or of an amputated uterus is buried, it has been taught that the stump of the appendix should be likewise treated. After salpingectomy or hysterectomy the ligated pedicle or raw surface is turned into well-vascularized tissue and can easily be absorbed or vascularized. The stump of a ligated appendix, however, is buried, not into solid well-vascularized tissue, but into the cavity of the cecum (Fig. 662). Adequate nutrition to injured tissue depends, among other things, partly upon the amount of damage to be repaired and partly upon the ease with which the blood circulation can approach the site of injury. In the simple treatment of the stump, the repair of the base of the appendix flush with the cecum is unobstructed. Not even a clamp that crushes the mucosa has been placed here and the blood supply comes to the ligated base without hindrance. The stump of the appendix which is ligated is, of course, necrotic material. It has probably been rendered aseptic by severing it with a cautery, curetting, and disinfecting it with carbolic This necrotic material to be successfully disposed of must be removed by phagocytes.

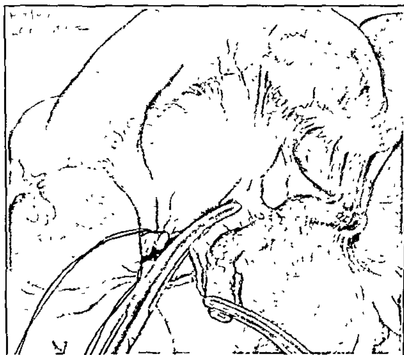


Fig 660 —The method of removing the appendix when it is difficult to deliver into the wound The base of the appendix is ligated, and the appendix is clamped near the base and divided with the electric cautery Both stumps are disinfected with pure carbolic, and the mesoappendix and the adhesions are clamped and divided from the base to the tip The first segment of mesoappendix, as shown in the illustration, has been clamped, divided, and tied, but usually all of the mesoappendix is clamped and divided before ligatures are applied.

In the simple treatment of the stump these phagocytes can approach not only through the unobstructed lymph and blood circulation of the cecum to the base of the appendix, but also can reach the stump by the peritoneum-covered fat sutured over it, by the omentum or through the mesentery of adjoining loops of bowel which may plaster over the stump In this way even an infection of the stump may be overcome by the vigorous and obstructed attack of the leukocytes. After the stump is digested and removed, the adherent omentum or mesentery drops away and leaves a smooth cecal wall which presents merely a slight scarring.

If we were to establish ideal conditions for the formation of an abscess, we would probably prescribe: first, the diminution of the blood supply to the tissues in which the abscess is to be located; second, the presence of necrotic material; and third, the formation of a closed sac. These conditions are filled when the stump of the appendix is buried, for the purse-string suture not only forms a closed sac in which the necrotic stump is enclosed but it cuts off some of the blood supply that must reach the base of the stump to produce repair, and thereby calls for a much greater hyperemia of the cecum than would otherwise be necessary. This excessive



Fig. 661.—The stump of the appendix is tied and a purse-string suture for invagination of the stump is placed.



Fig 662.—A sectional view shows the result of the invaginating method. The blood supply is partly cut off by the purse-string suture, a piece of necrotic stump is left in the closed cavity, and the mass of invaginated tissue can be almost surrounded by fecal contents. It is impossible for the omentum or mesentery to reach the stump of the appendix and a prominent lump is left in the wall of the cecum which may be a future source of ulcer or of cancer.

out the proper approximation of the deep structures, but no one would consider this good surgery. As to the ligature blowing off, this is much less likely to happen on the stump of an appendix than on a blood vessel. The stump of the appendix is soft and succulent tissue and the ligature sinks in well. The intracecal pressure never even approximates the blood pressure, so if any surgeon is capable of ligating a large blood vessel, he should surely be able successfully to tie the stump of the appendix. If, for instance, in an amputation of the thigh he applied a ligature to the femoral artery and this ligature slipped and the patient bled to death, the surgeon would not be justified in condemning the general method of placing ligatures on blood vessels, but he should assume that the ligature was not properly tied. If a ligature "blows off" the stump of an appendix, it is more the fault of a carelessly applied ligature than a reflection upon the technic of the operation that the surgeon attempted to follow.

Naturally, this method of treating the stump of the appendix does not necessarily apply to larger wounds of the intestine, and particularly to the treatment of the ends of the intestine when lateral anastomosis is done. Where the wound is large, and bears the brunt of the current of peristalsis, peritoneal surfaces must be approximated and ligation is not applicable, but in the appendix where the aperture is small and does not receive the impact of the current of intestinal contents, the simple method that has been described seems excellent.

When an abscess results from appendicitis or occasionally when peritonitis has developed, drainage is necessary. A small amount of murky, thin fluid when the appendix has not ruptured does not call for drainage, but in the presence of a distinct abscess or where the appendix has ruptured, particularly if the clinical symptoms show marked reaction, drainage should be employed. For acute appendicitis, particularly if there is to be drainage, the McBurney muscle-splitting incision is used. When there is a history of recurrent appendicitis or of a so-called chronic appendicitis, which may be accompanied by other lesions, a long incision near the median line is made unless the diagnosis can be quite clearly limited to the region of the *appendix and the terminal ileum. Chronic cases, as a rule, demand more thorough* exploration than can be done through a muscle-splitting incision, but in acute appendicitis the McBurney incision offers ample space for removal of the appendix and makes hernia after drainage much less likely to occur than if a right rectus incision were made. A hernia in drainage cases of appendicitis when the McBurney incision is employed is infrequent, and even if it occurs it usually gives but little discomfort and can be readily repaired; whereas with a rectus or median incision, especially if there is drainage, hernia is not uncommon

After making the McBurney incision and opening the peritoneum, the presence or absence of free fluid is noted The finger is inserted and the appendix is located by palpation If there are no adhesions, the cecum is pulled up into the wound and the appendix *is clamped near its base, if it is not gangrenous at this point. If, how-*ever, the appendix is adherent, and particularly if it is gangrenous and ruptured, it should be carefully isolated by the finger and brought into the wound with as much gentleness as possible to avoid any further spreading of the infection It is unwise to seize with an ordinary pedicle forceps an appendix that is strutted with pus or that has become gangrenous as the infiltrated tissue will almost certainly be cut through like cheese and the bleeding will smear the pus over surfaces that otherwise might not be infected In such cases, clamping the appendix should be avoided, and

only the mesentery should be clamped. This can be done by clamping the mesentery directly with curved Kelly forceps, or clamping across without crushing the appendix, using a Babcock forceps. If the mesentery cannot be found readily, it may be necessary to clamp the appendix, and it should be caught with light-bladed sponge-holding forceps with corrugations on the grasping surface. The forceps are not locked but are closed just sufficiently to hold the appendix while drawing it into the wound. Several sponge-holding forceps are used if the base is the first part of the appendix that is located. The first forceps seizes the appendix near the base, pulls it up, and another forceps seizes it lower down and makes further traction while it is being freed from the surrounding tissues with the fingers. In a very fat patient it is often difficult to recognize an infiltrated appendix because an infiltrated fatty tag or fold may so simulate it as to be very confusing. If the finger can find the line of cleavage and follow this without too much force, the tissues can usually be separated without doing any material damage. When an obstruction is met, no effort should be made to punch through it with the finger, but another line of cleavage should be sought. If an abscess is present, it is opened with the finger while suction is vigorously applied

The pus is emptied by suction and not by sponging. The stump of the appendix is then treated in the same manner as in recurrent or chronic appendicitis. Often it is impossible to tie the stump of the mesentery to the stump of the appendix because of infiltration with inflammatory products, but otherwise the technic is the same If the appendix has not ruptured but seems to be on the point of rupturing, the utmost care should be exercised to prevent it from bursting during the manipulations to deliver it, and the wound should be carefully protected with gauze.

When the appendix has ruptured and there is an abscess, drainage should be instituted. This usually consists of a single rubber tube with only one perforation near its end or a cigarette drain which is inserted down to the abscess cavity. When the abscess is behind the cecum, there is a great tendency for the infection to be carried to the posterior region of the liver unless the abscess cavity is freely opened and well drained. Here a cigarette drain of gauze in rubber dam, in addition to a soft rubber drainage tube, is carried into the abscess cavity. The drainage tube has an internal diameter of about 0.5 cm. The tube is sufficient to drain off the accumulated material in the peritoneal cavity and to cause a moderate reaction from the lymphatics, whereas the gauze that is carried to the abscess cavity produces a much more profound reaction upon the lymphatics and consequently a more marked reversal of the lymphatic circulation toward the abscess cavity than the rubber tube can effect In this way the lymphatics, instead of absorbing bacteria from the walls of the abscess and depositing them around the posterior region of the liver, will pour lymph into the region of the gauze drainage in an effort to extrude the gauze, and this is particularly important here in order to prevent subdiaphragmatic abscess. If this precaution is taken in abscesses located behind the cecum or colon, a subdiaphragmatic abscess will probably never occur. The drainage material is brought out at the outer angle of the wound. The tube is fixed in the wound by a single nonabsorbable suture in the skin. The rest of the wound is packed lightly with petrolatum gauze in order to prevent pocketing of the pus. If there is a quantity of pus and much suturing is done, the pus is very likely to pocket, and abscesses in the abdominal wall will develop Later, if necessary, the wound can be drawn together with adhesive plaster. Packing the wound lightly with petrolatum gauze often prevents any

suppuration in the raw surface even though pus drains over it, because the gauze causes a reversal of the local lymphatic circulation, which may be sufficient to prevent infection.

Frequently in the cases of acute gangrenous appendicitis, it is advisable to place a rubber tissue drain in the subcutaneous tissue, or to leave the skin open and unsutured. In such cases the peritoneal cavity is closed as usual and a rubber tissue drain is placed down to the fascia. The skin may be partially closed with interrupted silk sutures. This procedure will prevent the formation of a spreading infection or an abscess in the subcutaneous tissue. Drainage of the muscles or peritoneal cavity is unnecessary in these cases.

Five points for the routine treatment of all cases of acute appendicitis should be followed:

1. Immediate operation should be performed as soon as the diagnosis is made, in any stage of the disease, whether there is abscess or diffuse or spreading peritonitis.

2. The McBurney or gridiron incision is made and the appendix is removed. In removing an acute appendix, only enough adhesions are separated to give access to the appendix.

3. Suction is used instead of sponging. No gauze sheets or packs are used within the peritoneal cavity. Sponging out the pus with gauze forces the sepsis into the retroperitoneal tissues and should never be used in the presence of sepsis.

4. The stump of the appendix is treated simply, as has been described. It is ligated, severed, and disinfected, and a tag of fat may be drawn over it.

5. *Physiologic rest of the gastrointestinal tract is effected by limiting the oral* intake of fluid and avoiding proctoclysis entirely When there is local or spreading peritonitis, or when there is a perforation or abscess, the essential water and the electrolytes, with some calories, are given intravenously by 5 per cent dextrose in saline or in Ringer's solution. *If there is distention, the stomach is decompressed by* inserting a nasal tube to the stomach or duodenum; if the distention is great, continuous suction is employed

In the aftertreatment of these septic cases, the patient is elevated in bed, drainage is kept in until the temperature has subsided, and an abundant amount of morphine is administered. A heat tent or hot wet dressings are applied over the abdomen.

Antibiotics should be administered in these septic cases but are not necessary in the chronic or early acute cases The exact dosage and type of antibiotic should be determined by the bacteriologic finding in each case.

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# CHAPTER 59

# NONMALIGNANT CONDITIONS OF THE COLON

Carrington Williams and Carrington Williams, Jr.

## MEGACOLON (HIRSCHSPRUNG'S DISEASE)

Primary megacolon has been described by Bockus as "a great dilatation, elongation and hypertrophy of the sigmoid colon, involving at times the entire colon and rectum, associated with retention of enormous amounts of feces and an absent defecation reflex, due to a neuromuscular derangement of colonic function, usually of congenital origin." There are various types of secondary megacolon due to organic obstructions in the lower bowel which may be confused with primary megacolon but this discussion deals with Hirschsprung's disease or congenital idiopathic dilatation of the colon—the so-called primary megacolon.

This disease was described by Hirschsprung in 1886, and his name is permanently associated with it in medical literature. There were earlier cases reported, including one in the seventeenth century and many throughout the nineteenth century.

### Etiology

The etiology of Hirschsprung's disease is unknown although theories about it are numerous Some of the possible causes are as follows:

I. Mechanical Causes:
   A Valvelike folds of sigmoid mucosa.
   B. Malformations at the rectosigmoid junction.
   C. Aplasia of musculature of rectosigmoid.
   D. Congenital stenosis, atresia, or stricture of the rectum or anus.
   E. Spasm of anal sphincter due to local causes (fissure, ulcer, etc.)

II. Inflammatory Causes.

III. Deranged Nervous Mechanism:
   A. Hyperactivity of sympathetic nerves.
   B. Hypoactivity of parasympathetic nerves.
   C Paralysis of segment of gut.
   D. Absence of ganglion cells in Auerbach's and Meissner's plexuses.

There appears to be some congenital defect in the lower bowel which prevents the colon from emptying itself. This is followed by retention of feces and secondary hypertrophy and distention of the colon proximal to the rectum. It seems to be well established that Hirschsprung's disease is congenital in origin, and one instance has been reported in a seven-month fetus. Probably the best theory of etiology is that propounded by several authors who describe an achalasia of the rectal or lower sigmoidal musculature associated with degenerative changes in Auerbach's plexuses in which ganglion cells appear to be absent.

## Pathology

The pathology of the dilated portions of bowel is not specific. There i: usual type of dilatation and hypertrophy in any chronically obstructed bowel, Auerbach's and Meissner's plexuses appear histologically intact in this portic the colon. The sigmoid and other proximal portions of the colon become ‹ mously dilated and hypertrophied in the advanced cases of megacolon, and the d eter of the bowel sometimes has been described to be as great as 35 Classically the sigmoid is markedly dilated, but there is a sharp line of demarc: in the distal sigmoid or at the rectosigmoid junction beyond which the bowel pears to be normal or even slightly constricted. Histologic examination of the tum in such cases reveals the characteristic absence of ganglion cells in Auerb: plexuses described by Robertson and Kernohan and emphasized by Swenson. T facts together seem to indicate that there is a neuromuscular derangement of lower bowel resulting in functional obstruction and accounting for proximal di tion and hypertrophy. In addition there is at times a defective bladder mecha in patients with true Hirschsprung's disease, suggesting that a disturbance of parasympathetic nerve supply is the cause for this disease.

## Clinical Features

The clinical features of megacolon are characteristic. It is a rare disease, incidence probably being about 1 case per 10,000 autopsied children. Male dren predominate in recorded series. The disease usually is discovered in infanc early childhood, and the outstanding symptom is constipation. Bowel movem may occur very infrequently, and fecal impactions are common. As a result of stipation and impaction, abdominal discomfort, distention and pressure sympt are usually present. Dyspnea sometimes results from upward pressure on the phragm. Constitutional symptoms are headaches, irritability, restlessness, anore and slight fever. The disease is very chronic and may terminate fatally from ondary infection, pneumonia, intestinal obstruction, volvulus, or other compl tions

Physical examination reveals a somewhat asthenic individual who appears t underdeveloped and characteristically has a large "potbelly" Peristaltic movem are easily seen, and very often a large fecal mass may be palpated through the dominal wall. Rectal examination usually reveals an empty rectum and pro scopic examination does not often demonstrate pathologic changes in the rect It is more or less characteristic that the sigmoidoscope literally drops into the bo in advanced cases of megacolon.

Barium enema x-ray studies are very revealing. They should be carefully ried out and the technic of the Children's Hospital in Boston is advocated. A sn amount of barium is allowed to run in very slowly and under very light press while the patient is examined under the fluoroscope Usually in the oblique posit the barium may be seen to advance through what appears to be a normal rect and suddenly pass into a very dilated sigmoid colon. The significant feature is presence of a normal rectum and the appearance of the barium as it passes pelvirectal junction into the enormously dilated sigmoid If large amounts of b ium are run in under high pressure, the dilated bowel is filled immediately with barium, and the point of division between dilated and normal bowel is not visualiz

The diagnosis of megacolon is usually made without undue difficulty because of the history of obstinate constipation associated with marked abdominal distention beginning early in life. Complications of megacolon are volvulus of the dilated and hypertrophied sigmoid colon leading to acute obstruction, severe fecal impaction, and peritonitis.

### Medical Management

The medical management of primary megacolon usually is not very effective. Large enemas and various laxatives may help in promoting passage of the large fecal mass.

Parasympathomimetic drugs, such as Mecholyl, are reported to be of some value in promoting the tone of the lower bowel. It is recommended that the sphincter ani muscles be thoroughly dilated, and in addition other measures are employed to encourage defecation at a regular time every day. On this regime some patients may be carried along for an indefinite length of time, but in the case of true Hirschsprung's disease it is usually necessary to resort to surgical measures.

### Surgical Treatment

Several types of surgical procedures have been proposed for the alleviation of megacolon.

The first of these is colostomy. All authors agree that right transverse colostomy or some other type of drainage of the colon leads to a complete remission of symptoms; however, when the colostomy is closed, the symptoms invariably recur and the dilated bowel once again fills up with large amounts of feces. It has been noted that the dilated bowel ordinarily shrinks to a normal size following colostomy.

A second type of approach to the problem has been resection of the dilated and hypertrophied bowel. Advocates of this procedure claim excellent therapeutic results from the removal of the sigmoid and other distended portions of the colon; however, poor results are to be expected in cases where a neuromuscular derangement of the lower bowel exists.

A third type of approach to the treatment of megacolon is autonomic denervation of the lower bowel. This is accomplished by some type of sympathectomy and has produced moderately good results. Some indication regarding the possible effectiveness of this procedure can be obtained by barium enema studies before and after spinal anesthesia In many instances the dilated sigmoid is seen to empty itself fairly effectively after the administration of spinal anesthesia. Adson has advocated resection of the splanchnic nerves and bilateral lumbar sympathectomy, whereas Rankin and Learmonth resect the inferior mesenteric and superior hypogastric plexuses. This operation is similar to that used for dysmenorrhea except for removal of the sympathetic nerve fibers which course down from the aorta to the superior hypogastric plexuses and also extend along the inferior mesenteric artery to form the inferior mesenteric plexus. This plexus is removed along with the superior hypogastric plexus. In the hands of the proponents of these two types of sympathectomy the results are moderately good and some cures have resulted.

The most recently described procedure for the relief of megacolon is that of Swenson who believes that the difficulty is one of neurogenic origin due to absence of ganglion cells in the wall of the distal sigmoid and rectum. As has been noted, there usually is a fairly well-demarcated line between dilated sigmoid and normal

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sigmoid or rectum, and the nerve plexuses have been found to be normal in the dilated bowel. On the other hand, the normal-appearing distal bowel is deficient in the ganglion cells which are concerned with supplying the mechanism for defecation. In contrast to resection of the dilated bowel, Swenson believes that the distal or normal-appearing rectum should be resected as far down as the anal sphincter in order to do away with the deficient segment which interferes with the act of defecation. According to this concept a preliminary colostomy may be done in advanced cases for decompression of the bowel. If this is carried out, the site of demarcation between dilated and normal-appearing bowel must be marked with silk sutures because the dilated bowel undergoes regressive changes after colostomy. The definitive operation consists of division of the bowel at the point of demarcation and a resection of the distal sigmoid and rectum by a modified pull-through technic.

Resection of the distal bowel is carried out in one stage through a combined abdominal and perineal approach as follows: The patient is placed in a semilithotomy position, and the abdomen and perineum are draped separately for simultaneous operations. A left paramedian suprapubic approach is made and the abdomen is explored. The dilated colon is visualized, and the point of demarcation between dilated and constricted bowel is noted. Because of the absence of ganglion cells in the distal portion, the resection is always carried out to a point at least 12 cm. proximal to the line of demarcation. With the redundancy and hypertrophy of the bowel that is always present, there is no difficulty in obtaining sufficient bowel for its anastomosis in the perineum. Care must be taken in identifying the blood vessels supplying the sigmoid colon. The sigmoidal vessels are usually divided at their origin, preserving the arcades in the mesosigmoid for the supply of the end of the bowel The dissection is carried down in the hollow of the sacrum, mobilizing the rectum to the anal sphincters. It is advisable to keep the dissection close to the bowel walls so as not to injure the innervation of the bladder, and no attempt is made to remove the regional glands as in the procedures for carcinoma of the rectum. After the lower sigmoid and the rectum are completely freed, the sigmoid is divided between intestinal clamps at a point at least 12 cm. proximal to the junction of dilated and normal bowel. The sigmoid is resected from this point to the peritoneal reflection to facilitate pulling the rectum out through the anus. The proximal end of the rectum is then closed with continuous sutures and the suture ends are left long. The distal end of the proximal bowel is similarly closed and the ends of these sutures are tied to the sutures in the proximal end of the rectum The perineal drapes are then removed, and an assistant inserts a long Allis clamp through the anus up to the closed end of the rectum. This is grasped, and the rectum is pulled out and down in an everting fashion so that the mucous membrane presents on the outside. The rectal wall is incised approximately 3 cm proximal to the mucocutaneous junction, and by means of the long sutures the sigmoid is pulled down and out through the rectum. A careful anastomosis is then carried out between the sigmoid colon and the lower 3 cm. of rectum in two layers, and the remaining rectum which has been pulled through is removed. After completion of the anastomosis, the bowel is allowed to retract through the anus, and the anastomosis assumes a position about 3 cm. proximal to a mucocutaneous margin Meanwhile, the pelvic floor is reconstructed through the abdominal wound, and the abdominal incision is closed from above.

To reiterate, in the surgical treatment of megacolon there are two opposing schools of thought, one of which advocates removal of the dilated bowel with restoration of continuity, while the other advocates resection of the bowel distal to the dilated sigmoid and reestablishment of the continuity by a pull-through type of operation. Fairly good results have been reported following the first type of operation, while in Swenson's hands there have been excellent results in a series of twenty-six cases treated by the latter method Colostomy is used for preliminary decompression or as a lifesaving measure, and sympathectomy has been described as being of value in some cases of megacolon. At the present time it would appear that Swenson's method offers the best chance of complete surgical cure of Hirschsprung's disease

### Prognosis

The prognosis in megacolon depends to a large extent upon the type of management. Without either surgical or medical management it has been estimated that 85 per cent of the afflicted children will die; however, if the patient survives the first four or five years of life, prognosis for longevity is fairly good. Medical regimes have given moderately good results in about two-thirds of the cases, whereas surgical procedures have up to now given questionable results. It appears that Swenson's method of resection of the rectum with pull-through anastomosis promises excellent results and can be carried out with a moderately low mortality rate.

## DIVERTICULITIS

Diverticulosis or the mere presence of diverticula of the colon is found in from 5 to 10 per cent of all individuals over forty years of age examined at autopsy or by barium enema x-ray study. Of these about 20 per cent become infected so that diverticulitis of varying degree is a fairly common disease.

When diverticula are found, it is well to advise the patient to avoid strong catharsis and to attempt to regulate the bowels by a bland diet and the use of fluids, fruits, and lubricating inert substances so that the stools are formed but soft. Large enemas and colon irrigations should be avoided because there have been instances where the increased pressure in the lower bowel has resulted in perforation of one or more diverticula

### Cecal Diverticulitis

The solitary diverticulum of the cecum is a somewhat different condition. It is large with a small opening into the cecum and is subject to acute inflammation due to stasis Cecal diverticulitis presents a picture indistinguishable from acute appendicitis. When this condition is found at operation, the appendix is usually not involved. The inflamed diverticulum may be located on any part of the cecum, rather freely attached to the bowel or buried in varying degrees in its wall. This inflamed sac must be removed To accomplish this, it should be carefully dissected to its attachment, where in favorable cases a small neck is found which may be divided and its base inverted into the cecum. In more difficult cases the base may be large and the wall of the cecum so inflamed that a segment of the cecum must be removed in order that healthy bowel may be used for repair. When there is doubt of

the security of the closure of the cecum, ample drainage with multiple cigarette drains must be provided. Following this a fistula may develop which either will heal spontaneously or can easily be closed later.

### *Acute Sigmoidal Diverticulitis*

The ordinary diverticula of the colon are always multiple and increase in number to their maximum incidence in the sigmoid. It is in the left colon that practically all of the inflammation develops. This inflammation may be acute and develop without warning. The picture presented may be indistinguishable from acute appendicitis, but the pain and tenderness are usually located on the left side. If one is reasonably sure of the diagnosis of acute diverticulitis, the patient should be hospitalized and the bowel put at complete rest by gastric or small bowel suction and nutrition maintained by parenteral injections. The oral administration of Sulfasuxidine and Sulfathalidine and the parenteral use of antibiotics should be instituted. In a few instances the inflamed diverticulum may perforate into the peritoneal cavity, producing peritonitis. When such a situation occurs or is suspected, immediate operation is indicated. At operation it will usually be found that nothing more than adequate drainage can be carried out because the inflammation involves a segment of bowel which is so friable that suture is impossible. Exteriorization of this segment often is not possible on account of the extensive inflammation. It may be necessary to perform a proximal colostomy in the transverse colon for defunctionalization of the distal bowel, since nothing short of complete diversion of the fecal current is worth while.

### Diverticulitis With Abscess

The perforating diverticulum may be walled off and an abscess develop. As with the abscess of appendiceal origin careful observation is indicated. The abscess may drain into the colon and the inflammation subside, but if during observation it shows evidence of increasing in size, or if the systemic and local conditions do not promptly improve, drainage should be established. During the acute stage of inflammation all enemas of volume must be avoided, and diagnostic x-ray procedures should be postponed until the acute stage has subsided.

### Chronic Diverticulitis

The diverticulitis which is most commonly encountered is the mild recurrent and chronic inflammatory process in a segment of the colon, usually in the sigmoid Diverticulitis is always accompanied by varying degrees of spasm of the colon. The diet should be bland, and during the episodes of mild inflammation the proper sulfonamide drugs may be used Antispasmodic drugs are also helpful.

### Indications for Operation

Surgical interference is indicated in a small number of cases The inflamed colon not infrequently adheres to the bladder so that a fistula may develop. The warning that this may happen is given through the urinary tract and is indicated by bladder pain and urinary frequency, and these symptoms may be the first to indicate the presence of diverticulitis. When a vesicocolic fistula has developed, gas and feces are passed in the urine. When the first symptoms of bladder involvement are

recognized, proximal defunctionalizing colostomy must be established immediately. (See Chapter 60.) The patient is kept under close observation and the condition of the colon is followed by x-ray studies. The inflammation may subside and the bowel become so nearly normal, even when a fistula has been present, that after six months to a year the colostomy may be closed. In a large percentage of cases, however, resection of the involved area will be necessary. When this is undertaken, the condition of the bowel and the bladder will determine whether an immediate anastomosis or an obstructive type of resection should be done. When the inflammation is well localized so that the bowel ends after resection are nearly normal, end-to-end suture by the open method may be done. In the presence of a fistula the bladder may be closed or tube cystostomy established according to the local conditions. The proximal colostomy should be allowed to function until complete healing of the bowel has occurred and the presence of an adequate lumen has been established by x-ray examination.

External fistula results from drainage operations. Ample time should be allowed for it to heal spontaneously, and if this does not occur after a year, operation is indicated. Whether or not a proximal colostomy has been established, it is possible in some cases to dissect out the fistula and close the bowel, while in others it may be necessary to resect the involved segment. Restoration of the bowel continuity may be by the obstructive type or end-to-end suture as indicated by the condition of the bowel. The question of a preliminary proximal colostomy should be decided on the basis of careful clinical and x-ray studies of the condition of the bowel, but when doubt exists the colostomy should be done.

A few cases have been reported of fistulas between the sigmoid and small bowel. This may be a very disabling condition on account of the discharge of small bowel contents into the terminal colon. It must be corrected by operation In favorable cases resection of the small bowel and immediate anastomosis combined with resection of the involved colon and obstructive or immediate anastomosis can be carried out When there is obstruction of the colon and/or marked inflammation, an anastomosis should be made between the involved loops of small bowel, and colostomy established in the transverse colon. From this point the same indications would be followed as for simple inflammation.

The other indications for operation are persistent recurrent episodes of acute inflammation, cicatricial obstruction of the colon, the possibility of malignancy, and the occurrence of massive bleeding. Proximal defunctionalizing colostomy in the transverse or sigmoid colon, maintained for six months to a year, may give the inflamed area the rest necessary for recovery. If active diverticulitis persists, resection should be done as described above. When the original exploration is done, it may be necessary to resect the involved area. If there is any question of the condition of the bowel ends after resection, the obstructive type of operation should be done rather than primary union. When the resection is too low in the sigmoid to exteriorize the lower segment and the inflammation is too marked to allow primary union, the distal end of the bowel can be closed and the proximal end brought out through a small inguinal incision as is done for a permanent single-barrel colostomy. After several months the continuity of the bowel can be restored safely. Multiple-stage operations, as have been described, are tedious and to some extent disabling for the patient, but there is a very definite hazard in making an anastomosis when there is any question about the blood supply or the suitability of the two segments

for primary suture. In the event that edema of the bowel wall or questionable blood supply is present, there is much less risk in performing an exteriorization resection. It is desirable to construct a double-barrel colostomy with a spur which can later be crushed, but this is not always possible. The technics of the various types of colostomy and methods of resection are described in Chapter 60.

## VOLVULUS OF THE SIGMOID COLON

A condition which is clinically somewhat related to megacolon is that of volvulus of the sigmoid colon. This may occur as a complication in Hirschsprung's disease but also may occur independently and idiopathically. Volvulus of the sigmoid colon occurs usually in persons with abnormally long sigmoid flexures in whom the mesosigmoid is long and narrow. It is common among vegetarians and has been reported frequently in Europe and Asia. Volvulus of the sigmoid colon results in partial or complete intestinal obstruction which may be either acute or chronic. It is more common in older people, and the chronic type is more frequently seen.

When complete torsion of a redundant sigmoid flexure occurs, acute large bowel obstruction results, and the surgical correction consists of detorsion of the involved loop, with proximal drainage by cecostomy or colostomy and resection of the involved loop if indicated.

Chronic sigmoid volvulus presents a much more classical picture and is characterized by obstinate constipation, frequent attacks of bloating, visible peristalsis, and occasionally nausea and vomiting. The patients characteristically are underweight and not well nourished. Enormous distention of the entire abdomen with audible and visible peristalsis may be found, and yet the patient may experience little or no pain. Treatment of chronic sigmoid volvulus is usually carried out by the patient by changing position, such as to the knee-chest position, the use of large enemas, or merely by rest in bed. When detorsion occurs in these patients, the colon resumes more or less normal function. If chronic volvulus of the sigmoid colon persists for a number of years, the proximal colon becomes dilated as it does in megacolon. Acute episodes of volvulus can sometimes be relieved by the administration of enemas, by proctoscopy with passage of large rectal tubes, or by operative detorsion Elective treatment of patients subject to recurring volvulus of the sigmoid flexure consists of resection of the sigmoid colon and end-to-end anastomosis If there is great disparity between the lumen of the proximal bowel and the lumen of the lower sigmoid, delayed anastomosis can be carried out after an obstructive type of resection

The prognosis of volvulus of the sigmoid colon depends upon the stage during which the patient undergoes operation. In acute complete obstruction of the colon due to volvulus of the sigmoid flexure, the mortality rate is similar to that for any acute obstruction of the large bowel and necessarily is increased by gangrene due to complete torsion of the flexure. On the other hand, if resection of the sigmoid flexure is carried out for chronic sigmoid volvulus following adequate preparation, the mortality rate should be extremely low. Operations designed to fix the redundant sigmoid flexure to the abdominal wall have been unsuccessful and probably tend to increase the mortality in subsequent resection.

## INTUSSUSCEPTION

Various types of intussusception are described as enteric, ileocecal, ileocolic, and colocolic, depending upon the areas of the bowel involved. The most common type is the ileocolic or ileocecal, and approximately 75 per cent of this type occur in children under two years of age. In an adult this condition is almost invariably initiated by the propulsion of a tumor down the bowel lumen by peristalsis, producing an intussusception.

The clinical picture of intussusception is that of intestinal obstruction, either partial or complete, accompanied classically by the passage of blood by rectum. In children it is often possible to feel a sausage-shaped mass in the right lower quadrant representing ileocecal invagination of the bowel. In cases which are acute but incomplete, it may be safe to attempt to reduce the intussusception manually through the abdominal wall; however, particularly in children, patients with intussusception are often gravely ill upon arrival at the hospital and must be prepared for immediate surgical intervention. Wangensteen has advocated reduction of intussusception by means of a barium enema x-ray under moderate pressure, but this has been condemned by other writers If operative reduction is carried out, the intussusceptum (or the invaginated bowel) should be milked proximally by gentle pressure taxis on the outside of the bowel, and it is dangerous to *pull* the invaginated portion proximally. In cases of irreducible intussusception the procedure of choice is block resection of the intussuscepted area if the patient's condition permits, followed by anastomosis of the proximal and distal segments. If the patient's condition is too grave to justify this procedure, enterostomy can be carried out as a palliative procedure. Occasionally following enterostomy the intussusception will spontaneously reduce itself.

The prognosis in intussusception varies with the stage of the disease, the condition of the patient, and the extent of the operation. It is very unusual to see recurrent intussusception in an infant or a small child following reduction by operative means. On the other hand, if intussusception is caused by a small bowel tumor, it is very apt to recur unless the tumor is removed surgically.

## POLYPS AND POLYPOSIS

Polyps occur in the colon rather frequently. They are true tumors which grow from the mucous membrane and may be sessile or pedunculated. They are usually benign and may be classified as adenomas. They may occur in any part of the colon but their frequency increases toward the left side, so that a large percentage occurs in the lower sigmoid and rectum where they may be palpated or seen through the proctosigmoidoscope. These polyps are often multiple, so that, when one is found, the bowel must be studied thoroughly in an effort to discover others. Those occurring in the lower bowel are accessible to biopsy and when benign can be destroyed by coagulation or by snare as described in Chapter 61. Polyps located above the lower sigmoid can be diagnosed by barium enema x-ray examination which should always include pictures taken with air injection after evacuation. A foreign body or hard bolus of feces may simulate these tumors, so it is frequently wise to make repeated examinations to be certain of the diagnosis and of the location of the tumor.

Polyps should always be removed because of their tendency to undergo malignant change. When laparotomy is necessary, the entire colon must be carefully examined for tumors which may not have been disclosed by x-ray. The pedunculated polyp which appears benign can safely be removed by colotomy and division of the pedicle at the mucous membrane. The tumor should be examined immediately by a competent pathologist and if there is evidence of malignancy a generous segment of the colon should be resected. All sessile polyps should be removed by segmental resection for they are without doubt precancerous lesions. When such a tumor occurs low in the rectum and is pronounced benign by adequate biopsy, the problem is difficult. It may be impossible to do a segmental resection and anastomosis, so that the pull-through operation with preservation of the anal sphincter should be done. This operation should not be attempted unless the surgeon is well trained in its technic Colotomy and resection are described in Chapter 60.

When a patient has had single or multiple polyps, he should be examined at intervals by proctosigmoidoscopy and x-ray; this interval should be not more than one year.

Polyposis of the entire colon is a different condition. It occurs in certain families with remarkable frequency (Estes). This lesion probably begins as hypertrophy of the mucous membrane which goes on to polyp formation. The entire colon and rectum are usually involved and the general condition of the patient is seriously affected by loss of blood and loss of function of the colon. This lesion is also prone to become malignant so that it is important to remove the polyp-bearing area. Rarely this may be accomplished by segmental resection. More frequently the entire colon and rectum must be removed If the rectum is not too widely involved, it may be possible to destroy polyps in this segment by electrocoagulation so that anastomosis between the ileum and rectum can be done after colectomy. If this is done, frequent careful examinations of the lower segment must be made for recurrence or the growth of a malignant tumor.

In some cases of ulcerative colitis polyps develop in the affected areas; this is a clear indication for colectomy.

The problem of procedure in these cases is often difficult, and the same problem is presented in certain cases of ulcerative colitis when colectomy has been found necessary as a primary operation It must be decided whether or not a preliminary ileostomy should be done When the patient's condition is reasonably satisfactory, the one-stage operation should be done because the adjustment of the patient to the changes incident to ileostomy is often time-consuming and this delay is frequently undesirable

## BENIGN AND INFLAMMATORY TUMORS

Benign adenoma and the tumors resulting from diverticulitis and ulcerative colitis have been discussed in preceding sections The tumors now to be considered are quite rare but occur with sufficient frequency to be confusing from the standpoint of diagnosis and treatment.

Granulomas of specific and nonspecific origin occur in the colon and simulate malignant tumors both in history and x-ray findings; indeed at operation it is often difficult to differentiate between the two A specific lesion occurs in long-standing amoebic colitis and is probably as much the result of secondary infection in the

bowel wall as of the specific organism. If these masses fail to respond to medical treatment, the abdomen should be explored. The lesion may be so involved in an inflammatory mass as to be irremovable; proximal colostomy or ileostomy in reasonably healthy bowel should then be done. If, however, the lesion is well localized and free and the proximal and distal colon are in good condition, it should be removed. In all cases where the bowel is inflamed at the point of resection, immediate anastomosis is hazardous, so that the obstructive type of operation should be done.

**Syphilitic granuloma** occurs usually in the left colon and produces a sausage-shaped lesion. The bowel above and below the tumor is generally healthy so that an immediate anastomosis can be done.

**Nonspecific granuloma** is usually found in the right colon. It has been mistakenly considered to be of tuberculous origin but is probably similar to chronic terminal ileitis. This lesion may result from penetration of the bowel wall by a sharp foreign body such as a splinter of wood, pin, fragment of shell, or spicule of bone. Resection of the tumor is usually necessary and the type of repair must depend on the condition of the adjacent bowel.

**Lipomas, hemangiomas, and leiomyomas** have been reported. These tumors may cause obstruction by protruding into the lumen or by initiating an intussusception of the bowel. The submucosa is the site of origin of most of these tumors. Some of them are so situated that they may be locally excised and the continuity of the bowel preserved; others are diffuse or of such size that segmental resection is necessary.

**Endometrial implants** may grow on the pelvic colon and present difficult diagnostic problems Tumors from this source originate on the serous surface of the bowel and grow inward There is usually other evidence of endometriosis. These masses rarely cause obstruction and there is no indication for radical surgery except when obstruction of the bowel develops. As with other masses of endometriosis which are irremovable, the patient is treated conservatively. If symptoms of pain or impending obstruction develop, ovarian function can be destroyed by oophorectomy or radiation, this usually results in involution of the mass.

Endometriosis should be kept in mind by the surgeon because there have been unnecessary resections of the colon and even of the rectum when the tumor appeared grossly to be malignant. When there is doubt, biopsy should be done, and if this is not conclusive, the colon should be opened for inspection and biopsy of the mucous membrane.

## ULCERATIVE COLITIS

This disease is usually chronic but may occur primarily in an acute fulminating form or as an acute exacerbation of the chronic type. Its etiology is not known and the treatment is exceedingly unsatisfactory. The only indication for primary surgical interference is the severe acute case, where an early ileostomy should be done. In all others a medical regime should be established and the patients observed carefully for complications which might indicate a surgical procedure.

If in the course of treatment the general condition of the patient continues to decline, as measured by weight loss, uncontrolled anemia, and other symptoms such as pain and severe diarrhea, surgical treatment is indicated.

### Ileostomy

In these cases the primary operation is ileostomy. This is done by complete division of the ileum with the distal end closed or exteriorized according to the condition of the bowel.

If there is severe acute exacerbation during the chronic disease, as mentioned above, ileostomy must be done promptly, and this must also be performed when severe hemorrhage occurs. Other indications for ileostomy include chronic loss of small amounts of blood and progressive narrowing of the colon producing obstruction.

In the past the establishment of ileostomy has often been too long delayed, and this has been a major factor in the high mortality following operations on these patients. There is now a trend toward recognizing the hopeless condition of some and the development of complications in others, so that ileostomy is being done earlier under more satisfactory and safer conditions with resulting lower mortality.

When the ileostomy has been established it is exceedingly rare that it may be closed. Usually the best that can be expected is that the disease will improve sufficiently to allow the patient to gain weight, strength, and comfort sufficiently to lead a normal life. Many cases, however, continue active in spite of defunctionalization of the colon and develop complications which indicate radical surgery.

### Colectomy

In a few cases the disease may be so localized that a portion of the colon can be resected with promising results. This is very rare, however, and the surgeon must feel certain of the good condition of the remaining colon. In some cases the rectum is in good condition so that ileoproctostomy can be performed to reestablish continuity of the bowel In most cases removal of the colon and rectum is necessary, leaving the patient with a permanent ileostomy to which he has previously become adjusted.

Since the development of the pull-through operation with preservation of the anal sphincter, it has been proposed to pull the ileum through the anus, and this has been accomplished in a few cases Favorable reports of this procedure have been made by Ravitch and others.

The indications for colectomy are failure of the patient to improve after ileostomy, continued bleeding in small amounts, large hemorrhage, evidence of impending or actual formation of fistulas involving the bladder or small bowel, abscess and external fistula formation, episodes of acute exacerbations, the development of polyps, any suspicion of tumor growth, and systemic involvement of joints

In practically all cases the entire colon to the rectum must be removed, and in most the rectum too should be resected This formidable procedure should be done in stages according to the condition of the patient. The first stage is usually removal of the colon and the second stage abdominoperineal resection of the rectum. In rare instances the entire colectomy may be done at the same time The technic of this procedure is that of combining the segmental operations As in all benign conditions, removal of the pathologic tissue only is indicated, so that wide dissections to include the regional glands are not necessary. The bowel wall is frequently thin and friable, and therefore great care must be exercised to preserve its integrity

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# CHAPTER 60

# OPERATIONS ON THE COLON AND RECTUM

CARRINGTON WILLIAMS

## GENERAL PRINCIPLES

In the past, operations on the colon resulted in high mortality and morbidity. This has now been largely overcome, and in the hands of well-trained surgeons the most formidable procedures may be done with low mortality and little morbidity. The factors which have led to this improvement are:

1. Improved diagnostic methods regarding both the general condition of the patient and the local lesion.
2. Improved methods of rehabilitation.
3. The use of sulfonamides and antibiotics.
4. Improved surgical knowledge and technic.

The first three of these items will be discussed under Preoperative Preparation.

Increased knowledge and improved technic have come gradually over a period of many years. Any opening into the colon was considered so serious that Mikulicz developed the method of exteriorization of the involved bowel without resection This bowel was excised later, and, still later, the resulting colostomy was closed. This method was obviously inadequate for malignant tumors, so wider dissection, excision and open anastomosis were done The mortality was high and was attributed to soiling at the time of the open suture. Intraperitoneal vaccination for the creation of local immunity was advocated and widely practiced. Many methods of aseptic anastomosis were developed and used with satisfaction. Rankin and Lahey extended the Mikulicz operation to include wide dissection but exteriorization of the bowel ends rather than immediate suture All of these procedures were followed by a lowering mortality rate attributed by the advocate to his individual method.

It seems more probable now that the improvement came as a result of a better understanding of the problem and a better performance of the job by whatever method it was undertaken. Local soiling was probably never of serious consequence, and with the aid of antibiotics it is certainly not to be feared now. The soiling that caused peritonitis and death was due to leaking at the suture line. This is continuous and will be fatal, unless quickly corrected, with or without the modern supplemental aids. The most frequent cause of leakage is necrosis, and necrosis results from inadequate blood supply The first principle, therefore, in performing an anastomosis is to preserve an adequate blood supply to the ends of the bowel which are to be sutured. There are other factors too, such as inflammation of the

bowel, tension on the suture line, damage to the mesocolic vessels after the anastomosis has been completed, and anything else which would impair the good condition of the bowel ends.

The surgeon undertaking resection of the colon should have a thorough knowledge of the anatomy involved, particularly the vascular and lymph systems. The right and transverse colon come from the embryonic midgut; the arterial supply therefore comes from the superior mesenteric vascular tree by two large vessels—the right and the middle colic arteries. The splenic flexure, descending and sigmoid colon, and the upper rectum come from the embryonic hindgut and are supplied by the inferior mesenteric artery. The middle and lower rectum are supplied by the middle hemorrhoidal vessels from the hypogastric artery while the anal canal is supplied by the inferior hemorrhoidals from the pudendal arteries. The typical arrangement is the development of arterial loops with a free anastomosis between all vessels and a more or less continuous vessel in the mesocolon adjacent to the bowel. This marginal artery is very important in the preservation of adequate blood supply. These vessels are subject to so many variations that the surgeon should study them with care.

In general, the lymph channels and glands follow the blood supply so that in operations for malignant disease a wide excision of these areas is desired.

## PREOPERATIVE PREPARATION

The improved results from colon surgery in recent years have come as much from a better understanding of the importance of preoperative preparation of the patient as from the use of sulfonamides and antibiotics. When a patient appears to need an operation on the colon and is not obstructed, ample time is available for preparation A thorough general study must be made, which includes examination of the patient's general condition and the condition of the colon. Anemia and low protein and electrolyte deficiency of the blood should be corrected by appropriate feeding, supplemented by transfusion of blood as indicated. The colon examination by proctosigmoidoscope and barium enema x-ray should be thorough so that the nature and extent of the lesion and the condition of the rest of the colon are disclosed as far as possible. At the time of operation it is of the greatest importance to have the colon thoroughly empty and clean and the stomach and small intestine as empty as possible. To this end the patient should be hospitalized for from five to seven days before operation, and during this time the diet should be high in protein, low in residue, and abundant in vitamins. The colon should be irrigated at least once daily with abundant saline solution and Sulfasuxidine or Sulfathalidine given in full doses for four to six days before operation. Some surgeons use streptomycin by mouth but this is probably not necessary. On the day before operation a strong purgative, preferably castor oil, is given and only thin liquids in small amounts are given by mouth If the patient is fat or very muscular, it is wise to intubate the intestine with a Miller-Abbott or some similar tube; this should be started twenty-four hours before operation. If this is not used, a nasal stomach tube with suction should be inserted twelve hours beforehand in order to empty the stomach and to remove air swallowed during this period. This method of preparation should result in collapsed small bowel and a clean colon with low bacterial content During this period the patient should be informed of the possibility

of a temporary or permanent colostomy. If it is known that the rectum must be removed, the patient should be convinced of the necessity of the procedure and assured of leading a normal life with the colostomy. It is always most helpful to the patient to see and talk to a wise individual who leads an active and happy life with the same deformity. Finally, an adequate amount of blood should be available at the time of operation. Usually 500 c.c. are given routinely; if there is danger of considerable blood loss, as is always true in abdominoperineal resection of the rectum, more should be readily available.

When obstruction is partial or impending, the diet and length of time given to preparation should be modified to suit the condition. Purgation is important and should be used unless it might seem to affect the obstruction adversely. When the obstruction is complete, preliminary colostomy is indicated and no time should be lost, because with a competent ileocecal valve the colon, particularly on the right side, becomes enormously distended so that there is danger of perforation, and the decompression procedure is made more difficult and more hazardous by delay. The patient should be prepared as quickly as possible by transfusion of blood and infusion of fluids as indicated. The stomach should be emptied by intubation and suction, and it is usually not wise to attempt intestinal intubation.

X-ray examination by flat film will give useful information, and, when possible, the lesion should be located by barium enema x-ray examination. When any degree of obstruction is present, barium must not be given by mouth.

After the obstruction has been relieved by colostomy proximal to the lesion, the general methods of preparation modified by local conditions should be carried out. Oral sulfonamides may do little good but certainly no harm, and should be used. The colon should be irrigated through both the colostomy and the rectum. When restoration is adequate, the resection can be done, leaving the colostomy to be closed later.

In all cases it is essential that the bladder be emptied by catheter at the time of operation and in most cases it is wise to have the catheter in the bladder during the operation. In general, it is helpful to dilate the anal sphincter gently and to insert a rectal tube; this tube should be left free so that it may be advanced through the anastomosis or high into the left colon if necessary before the abdomen is closed

## ANESTHESIA

The anesthetic selected should give complete relaxation, for adequate exposure is essential. Spinal anesthesia given by the continuous method and supplemented by Pentothal Sodium intravenously is preferred by many surgeons. In expert hands it is unquestionably most satisfactory. For routine use, however, Pentothal Sodium induction with gas-oxygen and ether anesthesia, supplemented by the judicious use of curare, is preferred. General or spinal anesthesia is necessary when handling a patient with obstruction, because a thorough exploration consistent with the condition of the patient is important; however, in some poor-risk patients, where quick relief is indicated, colostomy may be done with local anesthesia

## OPERABILITY

Cancer of the colon confined to the bowel, or complicated by removable lymph node metastasis, should be extirpated by wide resection with removal of the regional lymph nodes. When irremovable involved nodes or distant metastases are present,

the decision for or against resection may be difficult. The problem of removal may also be complicated by local extension of the growth. Usually in these advanced cases the growth encircles the bowel so that obstruction is either present or impending. When the condition is thus incurable, the surgeon must decide for or against resection on the basis largely of whether or not the relief to be expected justifies the procedure, which may be quite extensive. One must also remember that much of the fixation to adjacent structures is inflammatory and not neoplastic. Again, if in order to remove the growth we must sacrifice adjacent organs, we must balance this mutilation with the resulting discomfort against the prospect of continued growth of the tumor. The objective of a palliative operation is to make the patient more comfortable and to prolong his life, unless both objects can be accomplished, the procedure is of little value and may actually be harmful.

## THE CHOICE OF OPERATIVE PROCEDURES

The first problem preceding operation is to estimate the degree of obstruction and to decide whether or not proximal colostomy is necessary. In most cases this decision is easily made, because in complete obstruction proximal relief is clearly indicated and without obstruction primary resection and anastomosis can be done. There are, however, borderline cases in which the obstruction is not complete or of very recent origin and which can safely be handled by primary resection, but in this type the obstructive method of anastomosis should be done. To be eligible for this plan the lesion should be in a mobile section of the bowel; most of them, therefore, are in the sigmoid, where a complete dissection with obstructive resection is not much more of a procedure than transverse colostomy The bowel can be opened for drainage almost immediately, and it is sometimes wise to insert a large catheter into the proximal loop near the obstructing clamp for immediate decompression. When there is doubt of the wisdom of carrying out resection, the idea should be abandoned and proximal colostomy done.

It should be a rule without exception that primary anastomosis by suture is not to be done unless the ends of the bowel are in prime condition, that is, not grossly affected by distention, inflammation, edema, or lack of blood supply. When there is doubt of the condition of the bowel ends, the obstructive type should be done. These considerations apply particularly to partial obstruction, diverticulitis, infected tumors, and other inflammatory conditions, such as internal fistula. There is another related procedure that will be found useful in dealing with the pelvic colon in the presence of inflammation When confronted by the indications for an obstructive type of operation in the pelvic colon with too short a distal loop for exteriorization, one can close the distal end and exteriorize the proximal end as a colostomy, preferably through a small inguinal incision Two or three months later the ends can be safely joined together at a secondary operation

When the lesion is in the right colon, it rarely obstructs the bowel and in most cases a primary resection can be done. This should include the terminal ileum, right colon, hepatic flexure, and the first portion of the transverse colon. Occasionally it is wise to do the ileocolostomy first and the resection later, as when the lesion is inflamed, obstruction is present, or the general condition of the patient is poor.

When the colon is resected for a benign lesion, it is obvious that the procedure should be less extensive than is necessary in the extirpation of a malignant tumor.

The dissection for benign lesions should be near the bowel in order to preserve the blood supply, and only the involved portion of the bowel should be removed, except that on the right side it is generally safer to remove the entire right colon and make the anastomosis between the ileum and the transverse colon. In the transverse colon the omentum can be preserved in benign lesions but should be removed in malignant ones.

Malignant tumors in the lower rectum should be removed by the radical abdominoperineal resection of the lower sigmoid and rectum. It is sometimes difficult to decide what tumor location in the lower sigmoid is satisfactory for anterior resection and anastomosis. There is a considerable number of surgeons who lean toward the anterior resection, but it should always be remembered that the objective of the *operation is primarily to cure the patient of cancer and secondarily to preserve the* continuity of the bowel. In this connection the pull-through operation with preservation of the anal sphincter has strong advocates. This procedure undoubtedly has a place in rectal surgery, particularly when one is dealing with benign or low-grade malignant lesions, but the operator must be familiar with the proper technic.

## COLOSTOMY

When obstruction due to cancer or to advanced inflammation or trauma results in distention of the proximal colon which cannot be relieved by treatment, it is necessary to decompress the bowel by some type of colostomy before carrying out definitive surgery. In marked obstruction it is not wise to attempt to resect the lesion and restore the continuity of the bowel, but a colostomy can be performed, and then resection can be accomplished with much greater safety after the obstruction has been overcome. The type of decompressive opening to be made in the colon depends largely on the nature and location of the obstruction. In this regard it is important to recall the physiologic functions of the colon and to recognize alterations in these functions due to incompletely obstructing lesions.

The ascending colon and cecum are large and thin-walled and serve the purpose of dehydrating the fecal stream after it passes from the small bowel through the ileocecal valve. The transverse colon and descending colon are more thick-walled and muscular and propel the bolus by peristalsis to the lower colon. In the sigmoid colon, the feces are stored in anticipation of defecation, while the rectum is concerned with storage and evacuation of the fecal mass.

Thus, obstructing lesions in the ascending colon must grow to a large size and cause complete blockage before the passage of the semiliquid feces is prevented. Lesions of the transverse and descending colons often are heralded by alterations in bowel habits and progressive constipation, and rectal growths usually are manifested early by bleeding.

Abdominal distention, pain, vomiting, and other symptoms and signs found in small bowel obstruction are late findings in large bowel obstruction, and incomplete or partial obstruction is much more common in the large bowel It becomes, therefore, imperative to recognize the symptoms and signs of large bowel obstruction before it becomes complete.

Complete obstruction of the large bowel usually demands emergency decompression by some type of colostomy prior to direct attack on the obstructive lesion The presence of an intact ileocecal valve often prevents retrograde distention of

the small intestine, until the intraluminal pressure causes relaxation of the valve. This retention in the colon with constant increase of its contents from the small bowel causes an enormous distention in late cases which may be very difficult to relieve. Vomiting is a late manifestation of obstruction of the large intestine and comes on only after retrograde distention occurs. If obstruction is continued long enough, fecal vomiting results. Pain is not so common a symptom in large bowel obstruction, particularly when due to carcinoma, but does occur in complete obstruction.

When the diagnosis of obstruction of the large intestine has been made, surgical treatment consists of preparing the patient for definitive relief of the condition causing the obstruction. In the case of volvulus of the sigmoid colon, intussusception, or some similar type of mechanical extrinsic obstruction of the colon, relief of obstruction may be indicated at the time of the primary operation. On the other hand, in cases of advanced obstruction with dehydration and depletion of the patient or when carcinoma or inflammatory disease is the cause of the obstruction, a decompressive operation may be necessary as a preliminary procedure. This decompressive operation consists of making an opening into the large bowel for temporary escape of the fecal content.

### Cecostomy

The simplest type of decompression of the large intestine is that obtained by cecostomy. This operation is easily done under local anesthesia and is indicated in complete obstruction involving the right side of the colon or advanced obstruction resulting from carcinoma in the left colon.

The operation is usually performed through a muscle-splitting incision of the McBurney type with local infiltration anesthesia. When the peritoneal cavity is entered, if the cecum is greatly distended and the wall very thin, it may be necessary to relieve some of the intraluminal pressure by inserting a small needle through the wall of the cecum for the purpose of deflation. When the wall of the cecum is in suitable condition before or after this type of deflation, the edges of the peritoneal opening are sutured to the serosa of the cecum with interrupted sutures of fine catgut. This effectively extraperitonealizes an area of the cecum which can be then used for the site of cecostomy. Ordinarily an area about the size of a silver dollar is thus extraperitonealized. Two concentrically located purse-string sutures of catgut are then placed in the bowel wall and held preparatory to the insertion of a tube into the lumen of the bowel. A small stab wound is carefully made in the center of these purse-string sutures, and a large rectal tube or mushroom catheter whose end has been trimmed off is inserted quickly into the lumen of the bowel. The purse-string suture on the inside is then tied and the long ends are cut, after which the peripherally placed purse-string suture is tied, inverting the first suture inward The tube is then effectively anchored in place and may be attached to suction or may be irrigated in order to deflate the bowel as much as possible. The external oblique aponeurosis may be closed with one or two catgut sutures loosely around the tube, and the rest of the wound is packed open with sterile gauze or can be closed at each end with a silk suture. If the cecostomy tube is kept open by frequent irrigations, very effective decompression of the bowel can be obtained.

Ordinarily the cesostomy tube will become loose in about six to ten days, and there may be leakage of feces around the tube at this time; however, the fecal cur-

rent may continue to emerge through this opening until the obstructive lesion has been removed. Another advantage of a cecostomy in cases of obstruction in the transverse or left colon is that it may be effectively walled off and kept out of the field at the time of definitive resection.

Following adequate decompression of the large bowel by cecostomy, the obstructing lesion in the colon distal to this point is dealt with by the operations described elsewhere.

## Transverse Colostomy

In cases of obstruction of the colon from inflammatory disease or previously determined inoperable carcinoma, it may be desirable to perform a more completely defunctionalizing operation for the diversion of the fecal stream. In obstruction in the left colon or in the sigmoid, a transverse colostomy may be easily performed. This can be done using local anesthesia, or if the patient's condition permits and further exploration is indicated, a light general anesthetic may be employed.

For the purposes of colostomy alone a small transverse incision is made in the upper portion of the abdomen either on the right or on the left side as circumstances indicate. The rectus muscle is divided so as to give adequate exposure, and the peritoneal cavity is entered. The omentum is identified and brought into the wound, and the transverse colon may then be brought into the field without difficulty. Fatty tags and omental attachments are divided along the area to be exteriorized. An opening is then made in the mesocolon immediately adjacent to the bowel, and through this a section of rubber tubing can be passed for traction purposes. The omentum can be replaced either superior or inferior to the bowel and is allowed to remain in the abdominal cavity. When a sufficient amount of the transverse colon has been cleared of attachments to the omentum, the rubber tubing is replaced by a small glass rod which passes underneath the bowel through the opening in the transverse mesocolon, and a short segment of rubber tubing is attached to the two ends of the glass rod. This rod is allowed to rest on the skin and prevents the bowel from retracting to the peritoneal cavity

If immediate deflation of the bowel is desired, a large catheter can be inserted into the proximal limb of the loop colostomy and attached to suction. On the other hand, the loop can be left closed for four to five days and then opened transversely to the axis of the bowel with a hot cautery. Troublesome bleeding is sometimes avoided by tightly tying a piece of umbilical tape around the bowel at the point to be divided when the loop is first brought out In this case the loop may be divided with a knife at the point of ligation with the tape and no bleeding results Complete division of the loop gives a very satisfactory double-barreled colostomy, but sometimes a moderate amount of spillage from the proximal to the distal limb occurs with this type of colostomy It is not necessary to fix the bowel to the abdominal wall if a glass rod is used, and there is usually no tendency for retraction of the limbs of the colostomy after the rod is removed.

## Sigmoid Loop Colostomy

In obstructing lesions of the lower sigmoid and rectum the simplest type of decompression which will allow limited exploration at the same time is a sigmoid loop colostomy A left paramedian exploratory incision can be made, and if a loop colostomy is then indicated, the sigmoid flexure may be brought out through a

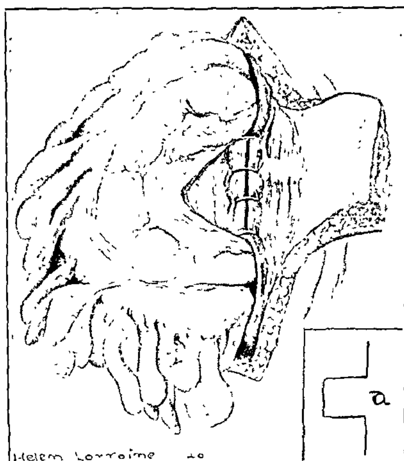



Fig 666.—Sigmoidostomy according to the method of Mixter. Inset *a* shows the lines of incision to secure a bridge of skin beneath the sigmoid.

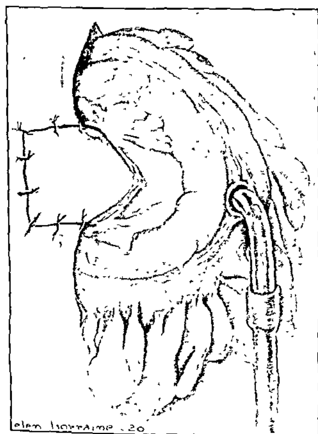


Fig 667

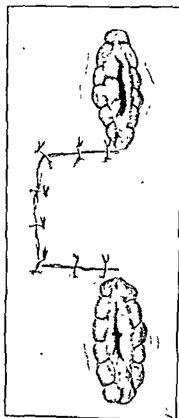


Fig. 668

Fig 667 —Sigmoidostomy with the bridge of skin sutured in position The sigmoid is opened and a tube is inserted for immediate relief of obstruction.

Fig 668 —Several days after the first stage of the operation, the bowel *is* divided or a section is removed, leaving an upper and a lower opening.

muscle-splitting incision in the left lower abdominal quadrant in a manner similar to that of a transverse colostomy. *A glass rod is inserted beneath* the loop through an opening in the sigmoid mesocolon, and the resulting loop is held extraperitoneally by means of the rod. The loop is then treated in a manner similar to that of other *loop colostomies.*

If at the time of exploratory laparotomy an inoperable growth is found deep in the pelvis, or if a permanent diversion of the fecal stream is desired because of inflammatory conditions such as lymphopathia venereum, a completely defunctionalizing sigmoid colostomy can be made after the method of Mixter. According to this method, the sigmoid flexure is mobilized sufficiently to allow exteriorization of 10 to 15 cm, and a large opening is made in the sigmoid mesocolon. The skin incision is made in such a way as to allow a bridge of skin and subcutaneous tissue to be drawn through the opening in the mesocolon so as to separate the proximal and distal limbs (Figs. 666 and 667). When the loop is divided at a subsequent date, the two stomas of the colostomy are separated by an intervening area of soft tissue and skin (Fig. 668).

## Double-Barreled Colostomy With Spur

In *some instances following resection of the colon or in conjunction with* a Rankin type of exteriorization procedure, it may be advisable to bring the proximal and distal segments of the bowel out as a double-barreled colostomy, and for ease *of closure the serous surfaces of the two limbs are closely approximated with sutures* in such a way that a common spur is formed between the proximal and distal stomas. At a future date when closure of the colostomy is carried out, the spur is *easily crushed and the colostomy closed by suturing the anterior wall of the bowel.*

## Single-Barreled Colostomy

In certain instances of resection of the large bowel for trauma or inflammation and in wide resections for malignancy, it is deemed inadvisable at the time of the primary operation to perform an immediate anastomosis. At the same time it may be impossible to bring the short distal segment of colon to the surface as a colostomy. In such an instance the distal portion of the bowel is closed in a method similar to that of closure of the duodenal stump during gastrectomy, and the proximal end of the bowel is then brought out through a separate opening or through the exploratory incision as a single-barreled colostomy. Obviously closure of this type of colostomy requires a complete laparotomy with restitution of continuity of the two segments of bowel.

## Colotomy

Occasionally it becomes necessary to remove from the colon a benign tumor, polyp, or foreign body This is usually accomplished by making a longitudinal incision through the bowel wall over the lesion to be removed, and this opening is then closed either *in a longitudinal or in a transverse fashion according to which* seems to give the best result In the large bowel it is not as important to close an opening transversely as it is in the small bowel, *for the lumen of the large bowel is* frequently adequate *in spite of some narrowing from* a longitudinal closure

## Closure of Colostomies

The operation of closing a colostomy is one which is commonly neglected in surgical textbooks, and descriptions of the procedure are lacking in detail. Although there usually is no great difficulty in closing a colostomy, occasionally the procedure is one of formidable proportions, particularly if there has been herniation of the exteriorized segment through the opening in the abdominal wall. It should be remembered that there always is a small ventral hernia associated with the loop type of colostomy and that wide dissection to repair this defect in the abdominal wall is necessary for adequate closure of the colostomy.

Closure of a cecostomy ordinarily presents no serious problem. In the type of cecostomy described above, very frequently the opening closes spontaneously when the continuity of the bowel has been restored at the time of definitive surgery. If the cecostomy continues to drain, it can be closed without extensive dissection by suturing the opening in the cecum with fine catgut in two layers and then closing the muscles and fascia over the wound with interrupted sutures, but leaving the skin unsutured.

Closure of a loop colostomy whether in a transverse or a sigmoid colon requires a moderate amount of dissection. The patients should be prepared adequately as for any type of colon surgery, and after preparation of the field, an elliptical incision is made around the margins of the colostomy, excising a small free edge of the attached skin. This is dissected from the edges of the bowel, and the margins of the colostomy are freshened. If the opening in the loop was made only halfway across the bowel, this opening is closed transversely with a through-and-through running suture of fine chromic catgut reinforced with interrupted mattress sutures of silk or cotton in the seromuscular coats. In the case of a completely divided loop an end-to-end anastomosis of the two stomas is made, and if the lumen appears to be small, it can be increased in size by a longitudinal incision in one free edge of each opening. This anastomosis is usually made with catgut for the inner row and silk or cotton for the seromuscular coats. Up to this point the operation is completely extraperitoneal. The area can then be prepared again and the drapes changed. Traction is applied to the exteriorized segment of bowel, and the adhesions between the bowel and the surrounding muscle and fascia are carefully separated so as not to injure vessels in the mesocolon or omentum After meticulous dissection of the bowel from the surrounding muscle and fascia, it may be possible to close these layers over the bowel without entering the free peritoneal cavity. On the other hand, if it appears that constriction would result from this maneuver, the peritoneum can be opened, and the entire loop dropped back into its normal anatomical position The peritoneum is then closed with catgut. The defect in the abdominal wall is then repaired by approximating the muscle with interrupted mattress sutures of fine steel wire or chromic catgut and the overlying fascia is similarly approximated. Because of the contamination which usually occurs during this procedure, the skin and fat are preferably left open and are closed in a very few days. This is particularly true if a transverse incision has been made, and for this reason a small transverse incision for a transverse loop colostomy is favored. It appears to be easier to close the ventral hernia in such a wound, and the skin edges fall together without sutures The open wound is then packed lightly with gauze, and dressings are applied.

Closure of a double-barreled colostomy with a spur which has been constructed at the time of the initial exteriorization is considerably simplified. The spur is crushed with an Ochsner clamp or with a special spur-crushing clamp for several days, and the diaphragm separating the proximal and distal limbs is thereby completely divided (Fig. 675). This allows closure of the colostomy by approximating the anterior walls of the bowel. This is accomplished with continuous catgut and interrupted mattress sutures of silk or cotton in the seromuscular coats and is carried out in a transverse fashion. Repair of the abdominal wall defect and replacement of the loop proceed in the manner described above.

Restoration of continuity of the bowel following a single-barreled colostomy necessarily entails a complete exploration and end-to-end or other appropriate anastomosis. This procedure has been described under resections of the large bowel

It should be emphasized that closure of a colostomy is often a formidable procedure and should be carried out with great care to avoid leakage from an insecure closure or from damage to the blood supply. If the edges of the colostomy are carefully freed the opening in the bowel usually can be closed extraperitoneally, and then after a suitable change of drapes, replacement of the loop into the abdominal cavity and repair of the abdominal wall defect are carried out.

When primary anastomosis is to be done, the choice of technic depends on the individual operator. There has been a decided trend to return to the old method of open suture (usually end-to-end, end-to-side, or side-to-side). The aseptic method still has many advocates It is of small importance which method is used provided the principles of sound surgery are followed. For malignant lesions radical removal of the bowel and adjacent mesocolon and omentum must be done. When the bowel is united it must be in good condition, free of infection or edema, and must have an adequate blood supply, and when the union is complete there must be no tension on the suture line.

## RESECTION OF RIGHT COLON; END-TO-SIDE ANASTOMOSIS; ILEOCOLOSTOMY

Lesions of the right colon are usually malignant, though granulomas are occasionally found here Terminal ileitis, which has been recognized in recent years, may also be an indication for resection of the cecum and ascending colon as well as the terminal ileum.

If any portion of the right colon is to be excised, it is best to remove all of the cecum and ascending colon, including the hepatic flexure This also is usually true of extensive lesions of the terminal ileum which may invade the cecum. A preliminary enterostomy or cecostomy is not helpful in resection of the right colon. If it has been determined that a resection of the cecum or right colon is indicated, the patient should be well prepared by treatment that will combat malnutrition, dehydration, and peritonitis.

An incision is made near the midline If it is definitely decided to do the excision in two stages with first an ileocolostomy and later a resection, the incision may be made to the left of the midline Usually, however, a long incision just to the right of the midline is quite satisfactory and permits better union of the abdominal wall than the incision farther to the right. With the abdomen open by an adequate incision, exploration should be done for evidence of extension of the

growth to the liver, lymph nodes, and abdominal viscera. This should always be done before the growth is examined. The lesion is then inspected and palpated, the tissues being handled as gently as possible, particularly if the tumor is large and adherent. It can then be determined at what point the ileum should be divided, and also the location of its anastomosis with the colon. A point about 20 to 30 cm. from the ileocecal valve is satisfactory. The mesentery of the ileum is incised. This point is selected with particular reference to the blood supply of the proximal ileum. It is important to leave a margin of mesentery outside the blood vessels to avoid injury when the mesentery is sutured.

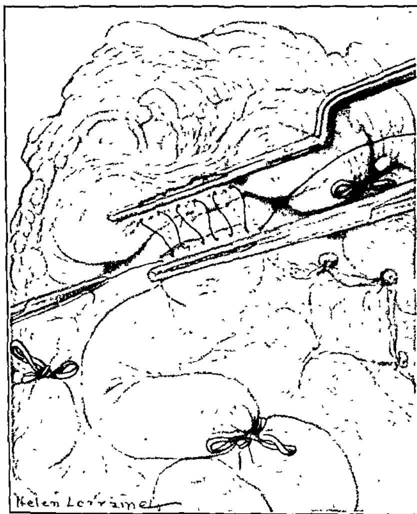



Fig 669—End-to-side union of the ileum to the transverse colon. The ileum has been doubly clamped and divided The undersurface of the right transverse colon is caught up with forceps until a pouch is made, and this is clamped and cut away. The ileum is preferably clamped so that its undersurface is covered with peritoneum. A basting stitch of silk is applied between the undersurface of the ileum and the transverse colon beneath the clamp Note the redundant mesentery of the ileum This is to assure sufficient nutrition to the stump of the ileum

A place in the right side of the transverse colon is selected for the end-to-side anastomosis The omentum is elevated and the part of the colon at which the anastomosis is to be made is clamped with a pedicle forceps after pulling up at this point a sufficient pouch of the bowel with Allis forceps or hemostats so that the stoma will be adequate This is usually between two longitudinal bands. The pouch of the colon is cut away with a knife or an electric cautery close to the clamp.

The colon just below this clamp is united to the stump of the ileum just below its clamp with a continuous mattress basting suture of silk or chromic catgut applied loosely, to be drawn tight later on (Fig. 669). Another similar suture is placed, between the upper portion of the colon above the clamp and the upper surface of the stump of the ileum above its clamp (Fig. 670). The ends of these two basting sutures are clamped together. The clamps are then gently removed as the two

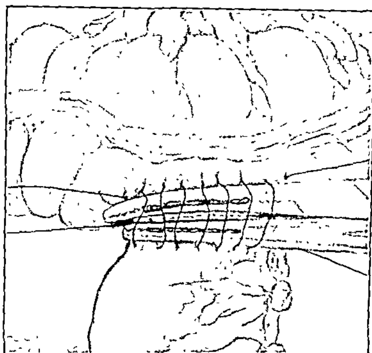


Fig. 670.—End-to-side union of the ileum to the transverse colon A similar basting stitch of silk or chromic catgut is placed between the upper surface of the stump of the ileum and the transverse colon above the clamp

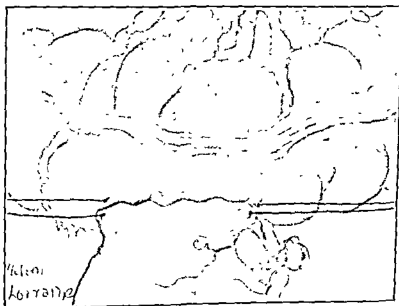


Fig. 671.—End-to-side union of the ileum and transverse colon. The ends of these basting stitches are held taut in the direction of the axis of the sutures The clamps are opened and withdrawn so gently that the clamped segment of bowel is not opened The ends of the posterior and of the anterior basting stitch are tied snugly together several times The wound is further reinforced by a series of interrupted mattress sutures of fine catgut or silk whose ends are passed through adjacent peritoneum-covered fat.

ends of the sutures on each side are drawn taut (Fig. 671). While the sutures are held in this position, their ends are tied together. These sutures are reinforced by other sutures, either a continuous suture or preferably a series of interrupted mattress sutures of fine cotton or silk. The ends of these latter sutures are left long, threaded in a needle, and passed through adjacent omentum and tied, thus reinforcing the union.

Particular care is taken to unite the mesenteric border to the lower portion of the transverse mesocolon.

In the one-stage operation the resection is begun by dividing the outer leaf of the peritoneum adjacent to the cecum and ascending colon and mobilizing this segment of bowel as much as possible by dry dissection. The ureter is demonstrated and carefully pushed out of the way. If the growth is extensive, it is very easy to injure the ureter while mobilizing or resecting the colon because it clings more closely to the peritoneum than it does to the posterior tissues. Before dividing the mesocolon, it is well to expose the ureter from the kidney down to the pelvis. The upper part of the mobilization is somewhat more difficult because there are intraperitoneal vascular attachments from the hepatic flexure upward to the liver and posterior peritoneum. These should be clamped and divided high. As the upper portion of the colon is dissected inward, the anterior surface of the duodenum is exposed and above it the common duct, portal vein, and hepatic artery must be protected. Occasionally the growth is attached to the duodenum; if this is not too extensive, the anterior duodenum may be removed with the colon. The duodenum is then repaired at once. This dissection is continued to the origin of the right colic artery. The whole dissection is then reviewed for blood supply to the terminal ileum and the distal transverse colon. Abnormalities of the ileocolic artery to the terminal ileum are frequent and the location of the middle colic is quite variable. Adequate blood supply to the remaining bowel is absolutely essential. Where doubt exists, additional bowel should be removed until its blood supply is satisfactory. When the vascular pattern has been studied, mesentery and mesocolon are incised between multiple clamps placed on the vessels to be divided. These vessels are ligated with catgut or cotton

Hemostasis should be complete before the colon is divided. The transverse colon is doubly clamped with pedicle forceps and divided with a knife or electric cautery. The terminal ileum is similarly clamped and divided. In clamping both, an angle between 45 and 60 degrees should be made to be certain of good blood supply along the antimesenteric border. A basting stitch of silk or cotton is placed over the clamp and is drawn snugly in the axis of the clamp as the clamp is carefully removed The basting stitch is drawn taut, and if the bowel is not too large the two ends are tied together, in this way bringing the bowel together somewhat as a purse-string suture. If it is impossible to do this because of fat or the size of the bowel, one end is threaded in a needle and a continuous suture is carried to the other end and tied. Then another row of sutures, preferably interrupted mattress sutures of silk or cotton, is placed, and the long ends of the sutures are threaded in a needle and passed through adjacent peritoneum-covered fat. If a purse-string suture can be used, several superimposing purse-string sutures should be placed and the long ends of the last one threaded in a needle and passed through adjacent peritoneum-covered fat. The outer purse-string sutures should not be tied too tightly, as otherwise necrosis will occur.

The area in the right flank is then reperitonealized as far as possible without tension. This usually cannot be accomplished completely and the uncovered area can safely be left and the incision closed. If, however, hemostasis is not complete, it is wise to insert a soft rubber drain through a stab wound in the flank. This drain should be well separated from all intestinal suture lines.

This description is of an aseptic or closed type of anastomosis The same procedure can be carried out by the Parker-Kerr basting stitch or by the use of other special instruments such as the Rankin, Stone, or Furniss clamps.

Many surgeons prefer the closed method, but more and more there is a trend to open anastomosis. The dissection and division of the bowel is carried out as described above. The anastomosis is begun by suturing the side of the colon to the end of the ileum behind the clamps with interrupted simple or mattress sutures of cotton or silk, including the serosa and muscularis. The clamps are removed and the ileum and colon are opened. The posterior edges are then sutured with continuous chromic catgut through all layers; this suture is tied at the end and continued on the anterior layer as a continuous Connell suture which goes through all layers and is tightened sufficiently to secure hemostasis. At the end of the line this suture is tied to the long end of the beginning suture. The anterior layer is protected by a row of interrupted simple or mattress seromuscular sutures of cotton or silk. It is frequently wise to place an extra suture at each end of the line.

This method of open suture may at times be modified by removing the clamps and suturing all layers with continuous catgut or interrupted silk first. When the bowel has been joined in this way, a proper toilet is carried out and the outside interrupted cotton, catgut, or silk sutures are placed.

Another method which may be preferred is lateral anastomosis between the ileum and transverse colon. To accomplish this, the end of the ileum is closed as well as the end of the colon, and corresponding openings are made in the colon between longitudinal bands and in the antimesenteric portion of the ileum after placing the posterior interrupted sutures of cotton or silk. From this point the suturing is done as described above

## RESECTION OF THE TRANSVERSE AND LEFT COLON

In resection of either the right or left colon, proper mobilization is essential. It is necessary to incise the outer leaf of the left mesocolon quite extensively and push the colon toward the midline. On the left side even more than the right there is danger of injuring the ureter in mobilizing the mesocolon The ureter should be well identified and separated from the mesocolon In the transverse colon if cancer is present, the omentum should be included in the resected portion of the bowel, but if the resection is done for other lesions than cancer, it is well to preserve the omentum This can be done by lifting up the omentum and separating it carefully from the anterior surface of the transverse colon Cancer of the splenic flexure is often difficult to excise because of poor exposure If the adhesions are at all extensive the lesion may be inoperable, but this cannot be determined until a thorough examination has been made

If the growth is not large or extensively adherent, resection with end-to-end union may be undertaken If the growth has been quite adherent, if the patient is fat, or if there is infection, an obstructive type of resection should be done.

First of all the liver should be palpated, and it should be ascertained whether there are any metastases at other points or any enlarged lymph nodes. Occasionally, when the mass is adherent to the abdominal wall, it may be dissected free, a part of the abdominal wall being removed along with the growth if necessary. This, of course, should not be undertaken unless there is an absence of metastases elsewhere.

Sometimes a local growth may appear quite extensive and slow perforation may have occurred in a comparatively mild cancer, such as the colloid type. The first impression may be that the case is inoperable, but on ascertaining the absence of metastases at distant points, the resection may often be justifiably undertaken, dissecting away the adherent tissues along with the tumor. Finally, if there are metastases in the liver and they are not very extensive, and the growth is obstructive or partly perforative, resection under these conditions is justifiable if the patient's general condition is satisfactory.

The preparation for a resection, whether it be an end-to-end union or an obstructive resection, is the same. A lateral anastomosis may sometimes be adopted according to the technic that has been described in surgery of the small intestine, but a lateral anastomosis probably gives no greater assurance of safety than the end-to-end method, and not infrequently it sacrifices the chances of cure by making it necessary to resect too small a segment of the bowel in order to have the ends overlap for the anastomosis. It is very rarely used.

The mesocolon is dissected in the manner described, the ureter is protected, and as the midline is approached the duodenojejunal junction is encountered. The mobilization of the splenic flexure may be difficult on account of the thick lienocolic omentum, but, as on the right side with the hepatocolic ligament, this is clamped high, divided and ligated. Along the descending colon the peritoneum is divided well away from the bowel in a manner similar to the right side. During this dissection the distribution of the middle and left colic vessels must be carefully determined, and in division of the mesocolon an adequate amount must be removed but the blood supply must be preserved.

When the mesocolon has been divided to the bowel, and the bowel has been cleared of fat, it must be definitely ascertained that the nutrition to the prospective stumps is satisfactory. To demonstrate this the end of the bowel should be incised to demonstrate active bleeding After ligating the mesocolon, not infrequently adjacent vessels are affected and this may not appear on superficial examination. The best test of the circulation is the actual demonstration of bleeding from the end of the bowel The blood supply to the large bowel is notoriously poor, and if it is seriously impaired, necrosis and perforation at the line of suturing will occur.

The affected loop is packed off from the surrounding tissue with moistened protective sheets At the line of proposed division of the bowel two stout intestinal clamps are placed at an angle from the mesocolon The bowel is divided between these clamps with a knife or electric cautery. These stumps are then approximated with the clamps still in position They are again packed around with moist gauze, with care that the gauze is placed snugly against the stump The clamp on the upper stump is slowly removed and the margins of the stump are caught with Allis forceps The stump is thoroughly cleansed with strips of gauze The other stump is similarly treated and the two stumps are approximated It is important that there should be no tension.

Fig. 672.

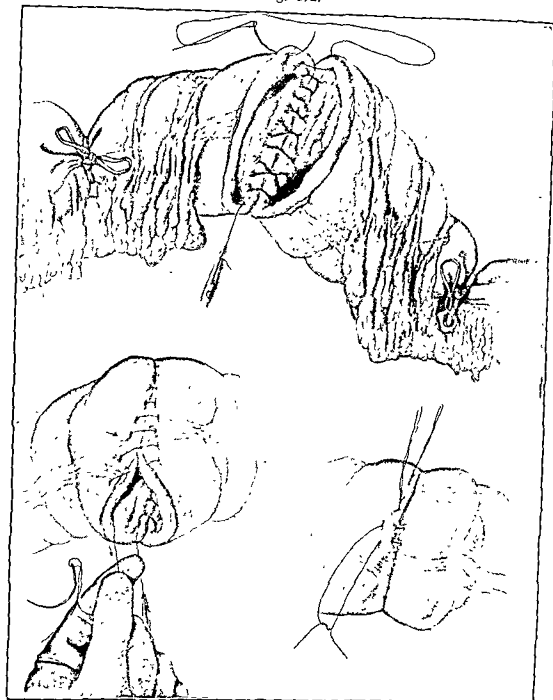


Fig. 673 Fig. 674

Fig 672 —The mesocolon has been severed and tied, and small rubber bands have been placed on the colon instead of soft-bladed clamps The ends of the bowel are being united as described in the text. Note the manner in which the suture in the anterior wall is being placed

Fig 673 —This represents a later stage of the preceding figure The stitch is drawn snugly at a line parallel with the wound, while pressure is made with the finger at a point indicated on the bowel by the arrow This tends to invert the mucosa, to approximate all walls of the bowel snugly, and to produce the same effect of the overhand stitch as if the bowel were sutured from within.

Fig. 674 —The first row of sutures has been completed and tied to the original end A second row of sutures, applied as interrupted mattress sutures, is then placed The ends are left long and later threaded in a needle and passed through adjacent peritoneum-covered fat

The ends of the bowel are sutured with catgut or silk beginning at the stump most distant from the operator and so placing the stumps that the mesocolic borders are side by side and not actually opposite each other. The suture is begun as a through-and-through suture in a curved needle, and the short end is clamped. Care is taken to see that the mucosa is not everted. The suture is continued as an over-and-over suture which is occasionally locked (Fig. 672), and, when half of the circumference of the bowel on each side has been united, the suture is tied and continued anteriorly (Fig. 673), being applied from within as far as possible and drawn snugly as it emerges from the mucosa on one side of the bowel while pressure is applied just posterior to the suture. This type of suture is described in operations on the stomach. It can be finished as a Connell suture and the end tied to the long end of the beginning suture.

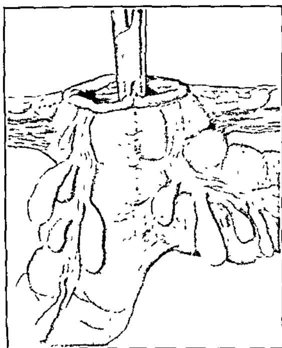


Fig. 675.—The second stage of obstructive resection The spur is caught with a clamp which should be left on for several days until the clamped portion of bowel has sloughed off The two limbs of the bowel have been previously sutured together and so are adherent to each other.

If there is any constriction at either end, a longitudinal incision for 2 cm. or more is made in order to enlarge the caliber of the constricted end of the bowel If the caliber in both ends seems to be too small, an incision may be made on each side. This suture is drawn quite snugly, as it is not only hemostatic but it should approximate the tissues closely. Around the whole circumference of the bowel is placed a series of interrupted mattress sutures of fine catgut or silk. The ends of all of these are left long (Fig 674). Particular attention is given to the sutures at the mesenteric border; they should be so inserted that the nutrition to this part of the bowel is not affected The long ends of each suture are threaded in a coarse round needle and passed through peritoneum-covered fat, usually the omentum, sometimes the adjoining fatty tags of the colon.

If the patient is fat and the growth large, an obstructive procedure may be elected. The loop of bowel to be resected is prepared as though an end-to-end

union were to be made. Its mesocolon is clamped, divided, and tied in sections. The loop is brought into the wound and its two limbs, which will form the stumps of the bowel, are clamped in a Rankin clamp and are sutured together with parallel rows of catgut sutures in the epiploica. These sutures must be so placed that they will not include in the plane between them the main nutritive vessels to the bowel, for otherwise when the spur is crushed the vessels may be destroyed and gangrene will result. The abdominal wound is closed up to and around the protruding limbs of the colon. The two limbs of the loop are not sutured to the peritoneum.

The two limbs of the bowel in the clamp are divided with a knife or cautery. The stumps are packed around with petrolatum gauze. The Rankin clamp is left in position until it drops off of its own accord if the operation has been preceded by a complete cecostomy on the right side. If there is no proximal colostomy, the clamp is left closed until the patient suffers from the obstruction. Usually this is between three and five days. When the clamp is opened, only the proximal blade is released After the clamp has dropped off in four or five days, or has become loosened, the spur formed by bringing the two stumps together, which resembles the partition between a double-barrel shotgun, is destroyed by the pressure of a clamp. The blades are inserted by palpation with the gloved finger into each limb of the colon, and the forceps is locked lightly at first. After twenty-four hours the forceps is firmly locked. (Fig. 675.) The pressure of the tip of the blades by this time will have sunk them into the spur in such a way that they will hold in place. In a few days more, the necrosis will be sufficient for the forceps to drop off. As soon as the spur has been well opened, the patient is discharged to return for closure of the colostomy when all inflammation has subsided. It is usually not necessary to open the peritoneal cavity to do this, but if on account of the thick abdominal wall it is found necessary to open the peritoneal cavity, this can be done without fear of peritonitis.

## RESECTION OF THE RECTOSIGMOID

Resection of the terminal sigmoid often presents considerable difficulty. The rectosigmoid junction is a region for frequent occurrence of cancer, and it is a problem whether an end-to-end union should be made or whether it would be better to remove the lower sigmoid along with the rectum, extirpating the whole rectum and making an artificial anus. The natural prejudice against a permanent artificial anus is understandable, and while it should not militate against the chances of cure, other things being equal an effort to reestablish the normal continuity of the bowel should be made On several occasions of making an end-to-end union after resection of the terminal sigmoid and upper rectum, we have employed a technic which seems to be satisfactory and apparently does not lessen the chances of permanent cure. A cecostomy, as has been described, is of value, particularly when obstruction is present. Entire relaxation should be obtained and good anesthesia is a necessity. The operation must be done in the Trendelenburg position.

Before the operation the rectum should be thoroughly cleansed with enemas and a tube left in the rectum. The abdominal incision is along the inner border of the lower left rectus muscle. Moist gauze sheets fastened to the parietal peritoneum in all operations on the large bowel tend to reduce the infection of the abdominal in-

cision which occasionally occurs after these operations. The sigmoid is mobilized as usual for the resection by dividing the outer leaf of its mesentery and pushing the sigmoid toward the midline. Here, particularly at the brim of the pelvis, care is necessary in order to avoid injury to the ureter, which must be identified. The mesocolon to the lower sigmoid is doubly clamped and divided in sections, which are then transfixed and tied with catgut. An incision in the peritoneum around the upper rectum is made somewhat as in the abdominoperineal resection of the rectum, only a little closer to the rectum. The superior hemorrhoidal artery is doubly clamped, divided, and tied with two ligatures of catgut on its central end. The tissues around the terminal sigmoid and upper rectum are mobilized posteriorly, with the hand in the hollow of the sacrum. Then the rectum is freed on the sides and in

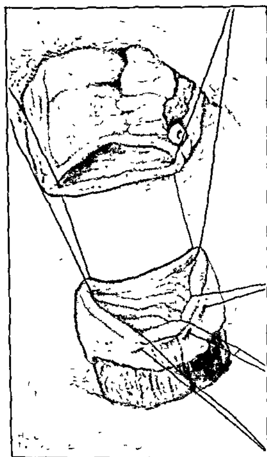


Fig 676 —The upper stump of the sigmoid is rotated so that its posterior *surface is* covered with peritoneum and the mesenteric border points to the left. *Two long tractor sutures* of silk or cotton are passed from the posterior surface of the upper stump through the posterior surface of the lower stump Three sutures are placed through the anterior wall of the lower stump *to act as* retractors

front Both ureters are carefully protected. When a point at least 5 cm. *below* the apparent lower margin of the growth is reached, the tissues are well packed off with moist gauze The upper limit of the loop is doubly clamped with pedicle forceps and divided Usually at the lower end there is not sufficient room to apply two forceps, so one large right-angled clamp is placed well below the lesion. Then the bowel is divided *below* the clamp. Any liquid that happens to be in the lower stump is removed by suction. However, if the rectal tube has been left in position, there is usually no accumulation of fluid The lower stump is carefully cleansed with strips of moist gauze. After removing the clamp, the upper stump is also cleansed.

In order to have peritoneum on its posterior surface, the upper stump is rotated so that the mesocolic border is to the left. The first suture is carried through the posterior surface of the upper stump from within outward and the upper end is clamped. The suture is then passed through the posterior surface of the lower

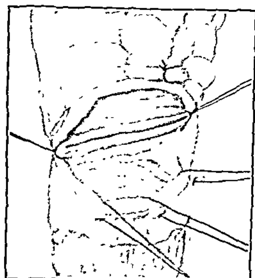


Fig. 677.

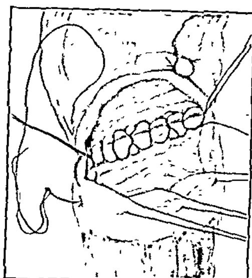


Fig. 678.

Fig. 677.—The upper stump is gradually pushed down to the lower stump as the long tractor or guy sutures are tied.

Fig. 678.—As traction is made on these two long guy sutures, the posterior margins of the two stumps are united with a continuous suture of silk. This takes a rather deep bite and is placed while the tractor sutures are made taut, so elevating the posterior margin of each stump. The suture begins on the left, and when the right side of the bowel is reached, the suture is continued anteriorly.

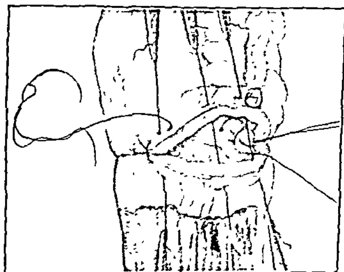


Fig. 679.

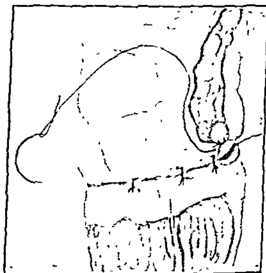


Fig 680

Fig 679.—Each of the three retractor sutures inserted in the anterior wall of the lower stump is now passed through the anterior wall of the upper stump. They are not tied but are held in such a manner as to lift up the anterior margin of each stump and render suturing easier

Fig 680.—As each of these tractor sutures is reached by the continuous suture, the tractor suture is tied and the continuous suture is carried along to the point of its commencement. By drawing this continuous suture snugly as it emerges from the mucosa of the lower border, much of the margin can be inverted It is tied to its original end The suture is reinforced by a series of interrupted mattress sutures, the ends of which are left long and passed through adjacent omentum or peritoneum-covered fat from the appendices epiploicae.

stump from without inward. The second suture, at a distance of about one-third of the circumference of the bowel from the first, is similarly placed. These two long tractor sutures of cotton or silk mark off about one-third of the circumference of each stump. The surrounding packing is removed, and the upper stump is shoved down to the lower stump There should be no tension. The sutures are tied, and the long ends are clamped and used as tractor sutures. Three sutures of silk or cotton are passed through the anterior margin of the lower stump. They are clamped and serve as retractors to expose the posterior margins that are to be sutured (Figs. 676 and 677).

Firm traction is made on each of the two posterior tractor sutures, so elevating the posterior margins of the apposed stumps; on the left side a continuous silk or catgut suture in a small curved needle is begun. The short end is clamped, and the suture unites the posterior margins of the bowel that lie between the two long tractor sutures. It is drawn snugly as it is applied, and particular care is taken to see that the mucosa embraced in this suture does not evert (Fig. 678). When the right tractor suture is reached, the continuous suture is carried forward and inserted from within as far as possible. It is drawn snugly as it emerges from the mucosa of the lower stump while pressing on the tissues just behind the suture. The three anterior sutures in the lower stump are passed through the anterior margin of the upper stump (Fig. 679). They are held taut and so facilitate suturing. After the continuous suture passes each of these tractor sutures, the tractor suture is tied and cut short (Fig 680). When the original end of the suture is reached, the thread is tied to this end several times and is cut short.

Around the bowel is placed a series of interrupted mattress sutures of fine catgut or silk It is probably impossible to do this posteriorly in every case, but the firm approximation with which the posterior margins are sutured renders mattress sutures in this region not so essential. Tags of peritoneum-covered fat from the adjoining tissue or from the sigmoid, or occasionally the omentum, are fastened around the suture line by passing through them the long ends of the mattress sutures. The peritoneum is then sutured around the bowel. The tube which had been placed in the rectum may be either removed now or advanced well above the line of anastomosis and the distal end fixed to the thigh with strips of adhesive plaster.

If hemostasis in the pelvis is not satisfactory, it may be necessary to place a drain. Usually a rubber strip is adequate, but it should not be close to the line of anastomosis and may be brought out through a stab wound adjacent to the incision.

## CARCINOMA OF THE RECTUM

It is impossible to make a rule for the treatment of carcinoma in the lower sigmoid and upper rectum either by measurements from the anus or by the distance above the peritoneal reflection in the pelvis. Each case must be decided on the local conditions found. The factors favoring an anterior anastomosis are adequate bowel below the tumor after mobilization of the sigmoid and rectum, a favorable growth from the standpoint of size, duration, and grade, and the absence of local spread On the other hand, when the tumor is complicated by distant metastases but is locally removable, anterior anastomosis can be performed as a palliative procedure In all other cases the abdominoperineal resection with abdominal colostomy should be done. When the condition of the bowel ends after resection is not fa-

vorable for immediate anastomosis or for the obstructive type of operation, the distal end may be closed by suture and the proximal end brought out as a colostomy, preferably through a small inguinal incision. At a later operation the anastomosis may be made under more favorable conditions.

### Abdominoperineal Resection

The left paramedian incision usually gives the best exposure; it should be of adequate length and the patient should be in a rather steep Trendelenburg position The usual exploration for metastatic extension is made before the tumor is approached. After careful inspection and palpation of the tumor, its operability is decided. The operation is begun by mobilizing the sigmoid along the left side, which is easily accomplished by dividing the peritoneal attachment and separating the soft tissues by blunt dissection. The peritoneal incision is then carried downward into the pelvis. The peritoneum on the right side of the bowel is then opened and dissected to the right lateral wall of the pelvis. The superior hemorrhoidal vessels are isolated and the point for division is selected after careful study of the blood supply to the left colon which will form the artificial anus. The vessels are doubly clamped, divided and ligated with catgut. The soft fascia can then be easily separated from the hollow of the sacrum and by finger dissection the entire rectum is lifted anteriorly until the plane of the levator muscles is reached During this dissection the ureters are exposed and carefully preserved. The two lateral incisions in the pelvic peritoneum are then joined anteriorly under the bladder in the male and behind the vagina in the female and the dissection is continued anteriorly and laterally. The lateral attachment contains the middle hemorrhoidal vessels and can usually be divided between long clamps and ligated The ureters must be carefully observed before these clamps are applied. This mobilizes the entire rectum and by further blunt dissection it is separated to the levator muscles in all directions.

The level for division of the bowel is then selected and its blood supply checked. At a point lateral to the rectus muscle, where the proximal bowel can be comfortably withdrawn from the abdominal cavity, a circular incision, 2.5 cm. in diameter, is made This skin and underlying subcutaneous tissue are excised; the muscles and the peritoneum are incised. Through this incision a stout clamp is inserted and clamped across the sigmoid at the level previously selected Another clamp is placed closely parallel to this through the original incision, and the bowel is divided with a knife or the electric cautery. The upper clamp is then withdrawn through the small incision so that about 2.5 cm. of bowel is exteriorized. (Fig 681.) It is sometimes desirable to bring outside an excess of bowel, which can be easily reduced to the proper length later. The sigmoid is fixed to the lateral wall with a few sutures of catgut or cotton placed in fat tags and peritoneum. No sutures are placed in the bowel in the abdominal wall; it is rarely necessary to bring the peritoneum snugly around the colon. The distal segment is sometimes too bulky to be covered by the pelvic peritoneum and can be reduced to a comfortable size by another division at a lower level The distal end is prepared by ligation with heavy tape below the clamp which is then removed. This stump is then covered with a small rubber glove or large Penrose drain to prevent soiling of the pelvic cavity. This protective covering is held in place by several stout ligatures The pelvic peritoneum is now sutured with chromic catgut. Sometimes it is necessary to mobilize the peritoneum rather freely and to suture it in a T shape (Figs. 682 and 683 ) In women the suture

line may be reinforced by fixing the uterus and adnexa over it. Sometimes in women it is necessary to remove the uterus and adnexa with the rectum. When this is done, the vault of the vagina should be closed with care and covered with peritoneum in order to prevent the vagina from opening into the cavity in the pelvis below the peritoneum The abdominal incision is then closed and isolated by dressings from the colostomy. Strips of plain or petrolatum gauze are placed around the exteriorized bowel and tucked loosely into the wound. The clamp is protected by the dressing and fixed to the abdominal wall.

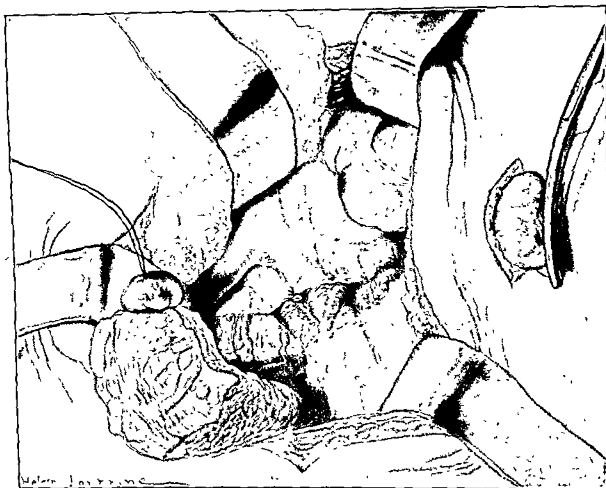


Fig 681.—The mesosigmoid has been divided and the vessels are tied. Dissection has been made around the upper rectum, *mobilizing it.* The upper stump should be clamped, as described in the text, and is brought through the abdominal wall for a permanent colostomy. The lower stump is pushed down in the pelvis and the peritoneum is sutured over it.

The patient is then placed in an exaggerated lithotomy position. This position gives good exposure for the posterior excision and requires the minimum movement of the patient which is desirable for the prevention of shock. In the male patient it is frequently advisable to insert a urethral sound and keep this in place during the dissection around the prostate and base of the bladder. The anus is closed with a stout purse-string suture and an elliptical incision is made around it. Through this incision the dissection is carried laterally and posteriorly. On each side in the subcutaneous tissue the *inferior hemorrhoidal* vessels are found. They are clamped, divided, and ligated with catgut. The levator muscles are now exposed and divided transversely just anterior to the coccyx. This opens the field dissected from above. The muscle is then divided on each side between clamps which are placed close to

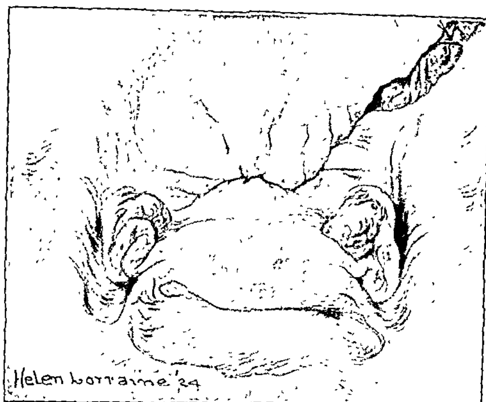



Fig 682.—Appearance of the pelvis after completion of the abdominal stage of excision of the rectum.

Fig 683.—Section showing the lower stump of the sigmoid and the upper rectum in the pelvis with the peritoneum closed and the upper dissection completed The perineal portion of the operation is then done.

the wall of the pelvis; the rectum is then delivered into the wound and pulled downward. This maneuver facilitates the dissection of the bowel from the prostate, which may not have been completed from above. At times there is troublesome bleeding from the numerous veins around the prostate, but when the rectum has been completely removed this can be controlled. A sheet of rubber dam is then inserted into the cavity and a roll of wide gauze is loosely packed into it. This drain is placed in the posterior angle of the wound. If the perineal wound is comparatively dry, one Penrose drain instead of the packing may be sufficient. The rest of the wound is closed with several interrupted sutures. Some of the gauze is removed after forty-eight hours, and the remainder, including the rubber dam, after seventy-two or ninety-six hours. The care of the posterior wound is simple. Irrigation may be used according to the wishes of the individual surgeon, and it is not necessary to use it daily. An indwelling catheter should always be placed before the operation is begun, and this is left in place for about one week. After the catheter has been removed, the function of the bladder may be poor. This is especially true in elderly male patients who have varying degrees of prostatic hypertrophy, and it is occasionally necessary to resect a portion of the prostate before satisfactory bladder function is established. The colostomy can be opened after twenty-four hours, but in well-prepared patients without obstruction it can be closed for several days in order to have solid healing of the wound and secure adherence of the exteriorized bowel in the inguinal incision.

## CHAPTER 61

# OPERATIONS FOR NONMALIGNANT DISEASES OF THE RECTUM AND ANUS

ROBERT V. TERRELL

## *HEMORRHOIDS*

Hemorrhoids occur about the anus and lower rectum as swellings composed of clusters of varicose veins and are usually three in number, though as many as nine may be present. The location follows the distribution of the branches of the superior hemorrhoidal artery and are quite constant in three main positions, a left, a right anterior, and a right posterior. Regardless of how many hemorrhoids may be present, they may be satisfactorily removed surgically in these three or, at most, four groups. Hemorrhoids may conveniently be classified as external, internal, and a combination of these two, termed combined or mucocutaneous hemorrhoids. *External hemorrhoids* develop in the anal canal and are covered with stratified squamous epithelium. This epithelium lacks sweat glands and hair follicles but is richly supplied with sensory nerve endings so that even minor disturbances are capable of producing great pain. *Internal hemorrhoids* lie within the rectum, are covered with mucous membrane and are relatively insensitive. Even though a hemorrhoid may protrude outside the body, it is still an internal hemorrhoid if covered with mucosa. The mucocutaneous line or juncture separates internal and external hemorrhoids; recognition of this line is extremely important in the injection treatment of internal hemorrhoids. Near this line fibers of the longitudinal muscle pass between the internal and external sphincters and are ordinarily rather firmly attached to the anal skin, producing a slight depression. In many cases this attachment becomes weakened so that the swelling of an internal hemorrhoid is continuous with that of an external hemorrhoid, producing the *mucocutaneous hemorrhoid,* which is partly anal and partly rectal and protrudes readily Although patients are seen who have only internal hemorrhoids and others who have only external hemorrhoids, usually both are present in some degree in the vast majority of cases and most often are of the *mucocutaneous* variety.

### *Acute Thrombotic External Hemorrhoids*

This condition is usually seen as a painful, red or bluish swelling of an external hemorrhoid, which develops suddenly during or after a difficult bowel movement or diarrhea. Such a condition is also frequently a complication of pregnancy but may be precipitated by alcoholic excesses, the use of laxatives, or some unusually strenuous exertion. Most often the clot forms within the lumen of the vein and varies in size from a few millimeters to as much as 5 cm. in diameter A single hemorrhoid

will often contain one or two clots the size of a green pea, but occasionally a dozen or more small shotlike thrombi are present. Ordinarily the clot is confined to only one external hemorrhoid, but sometimes thrombosis occurs in two or more hemorrhoids simultaneously. The presence of a clot or clots within the hemorrhoid interferes with the circulation, producing a mechanical inflammation often accompanied by intolerable pain due to the tension produced within the tissues. If the clot lies deeply within the hemorrhoid, considerable edema of overlying tissues may result. When untreated, large clots close to the surface will sometimes produce ulceration and necrosis of the overlying skin with spontaneous rupture and partial discharge of the clots. If this has happened when the patient is first seen, the physician should simply complete the removal of the clot by gentle pressure, or it may be necessary to enlarge the opening and pick the thrombus out with forceps; often this can be done easily without anesthesia. In the majority of untreated cases slow resolution with ultimate replacement of the clot by fibrous tissue will occur, creating the so-called "*hemorrhoidal skin tag,*" which is a permanent deformity consisting of a redundant fold of wrinkled skin, making the anus difficult to clean and predisposing to pruritus. Skin tags may also be produced as the result of long-standing infection as in pruritus ani or by infection in a postoperative anal wound. Treatment of an acute thrombotic external hemorrhoid will depend somewhat on the size or number of thrombi as well as the duration of the attack. If the patient is first seen several days after the onset, with a history of marked improvement, and examination shows the thrombus to be small and undergoing absorption, the wound created in excising such a thrombus would most likely produce an exacerbation of symptoms. Therefore, in such cases it is generally better to prescribe an intestinal lubricant by mouth, local applications of heat, and a soothing ointment such as Diothane or boric acid to promote further the processes of absorption. An ointment applied with the forefinger is more beneficial than suppositories, as the latter go beyond the painful anal area into the insensitive rectum, though they do lubricate and facilitate defecation. Excision of the thrombus in indicated when it is producing pain, if its eventual rupture through the skin appears likely, or if it should be of such size that absorption of the clot and ultimate replacement by scar tissue would almost certainly leave an annoying skin tag. Removal of the thrombus can be expected to bring prompt relief and can easily be performed in the office. A satisfactory technic is as follows: with the patient on the examining table in the left Sims' position, the buttocks are widely separated and excessive hair is clipped away. An antiseptic is applied and a local anesthetic solution is injected into the overlying and surrounding tissues, 1 or 2 c c of this solution usually being sufficient. A word of warning at this point is pertinent; before undertaking the treatment of any obvious anorectal condition, it is wise to perform first a complete examination of these organs, including the passage of the sigmoidoscope, in order to avoid overlooking some more important condition. An excellent time for this procedure is while the anesthesia is present Often the patient will have voluntarily suppressed the urge to defecate and the rectum will be packed with feces which he may now expel by normal bowel movement or enema more comfortably than later. On completion of the examination the skin overlying the thrombus is picked up with a hemostat and an elliptical wedge is excised. The clot or clots and superficial varicosities are then removed and excessive skin edges are trimmed away, leaving a smooth radial wound. In this way drainage is established without packing and the clot will not reform from any oozing

that might occur, as it will often do if the skin is simply incised and clots are removed. Bleeding vessels may be clamped and ligated, but in many cases this is unnecessary. If the thrombus occurs in the anal canal below an anal papilla, it is sometimes wise to excise the papilla along with the clots, lest it undergo inflammation and hypertrophy, producing both pain and delayed healing. The wound is left open and no drains are used.

Wound care is made as simple as possible so that the patient himself may perform it without dependence on others; daily defecation is encouraged, using Metamucil or liquid petrolatum if necessary; purgatives should be avoided. Careful cleanliness with soap and water, local applications of Diothane or boric acid ointment several times daily, and hot Sitz baths are helpful A very small fluff of absorbent cotton inserted into the anal verge will absorb any discharge and reduce irritation; such wounds should heal in a few days. Occasionally it is necessary to remove two or three widely separated thrombi by as many incisions, but in most such cases a complete hemorrhoidectomy in a hospital would be indicated.

## Internal Hemorrhoids

Internal hemorrhoids are practically insensitive, but bleed easily and freely and should not be overlooked when seeking the cause of a secondary anemia which in rare instances may be extreme. As hemorrhoids grow larger, they tend to protrude

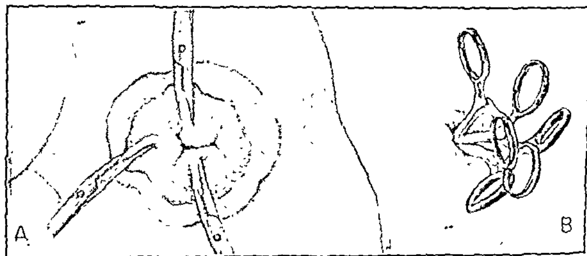



Fig 684.—Reduction of strangulated hemorrhoids Each prolapsing internal hemorrhoid is grasped with a hemostat (*A*) and all are simultaneously replaced within the rectum (*B*). As the forceps are released, a wad of cotton is firmly applied to the anus and held in place by a snug "T-binder" to prevent recurrence of prolapse

outside the body at defecation, on strenuous exertion, or when unusual positions, such as squatting, are assumed. If the internal hemorrhoids remain protruded outside of the anus, being caught in the grasp of the anal sphincters, the obstruction to venous return will produce swelling and thrombosis of both internal and external hemorrhoids. This complication is known as strangulation and, if not soon reduced, necrosis of tissues will follow. Strangely enough in gangrenous strangulated hemorrhoids the anal sphincters are usually relaxed when the patient finally consults the physician.

Treatment of this complication is disputed by experts; some authorities advise bed rest, hot wet compresses, and general supportive treatment until the necrotic

tissues slough away. They do this for fear of releasing pyemic emboli to liver or mesentery. Although this possibility is conceded, the author prefers immediate hemorrhoidectomy in most cases, thereby bringing relief of pain and reducing loss of time from work. If the patient is seen early before extensive thrombosis occurs, reduction can generally be accomplished in home or office in the following manner: with the patient in a left Sims' position, a few drops of local anesthetic agent are injected into each internal hemorrhoid. Each internal hemorrhoid is then firmly grasped with a hemostat (Fig. 684, *A*) after which all three are pushed into the rectum simultaneously (Fig. 684, *B*). A wad of cotton firmly applied to the anal orifice will prevent recurrence of the protrusion, as one by one the hemostats are carefully removed. A few drops of Quinuride are then injected into the superior poles of each internal hemorrhoid above the protruded area, after which the cotton wad is reapplied to the anal orifice and a "T-binder" is snugly applied. In some cases it is necessary first to excise one or more external thrombotic hemorrhoids before the strangulation is reduced; in other cases thrombi may be removed from internal hemorrhoids as well. In general, it may be said that when strangulation has occurred, eventual hemorrhoidectomy will be necessary.

## INJECTION TREATMENT

Injection treatment of internal hemorrhoids remains a controversial subject; some authorities will concede no merit to the procedure, but stress its dangers and report serious complications. Others are enthusiastic in its praise, reporting successful experience over many years without serious complications. The facts are that the symptoms of bleeding and protrusion can be at least temporarily improved in almost all cases when internal hemorrhoids are skillfully injected. Lasting cure will often follow the injection of small or medium-sized internal hemorrhoids which have not been protruding over too long a period. Complications other than drug sensitivity are most often due to errors in technic and are therefore generally avoidable. Failures to cure are usually the result of inadequate treatment or to faulty judgment in selection of cases Advantages of the method are that hospitalization is not required, and by it some measure of relief can be given the aged or seriously ill for whom surgery would be hazardous. The aim of therapy is the creation within the hemorrhoid of a reticulum of fibrous tissue which will enmesh and obliterate the varicosities of which internal hemorrhoids are composed. Although many sclerosing drugs are available for this purpose, Quinuride, a 4.5 per cent preparation of anhydrous quinine urea hydrochloride, is considered the most satisfactory. Where protrusion has been occurring over a long period of time, and especially where hemorrhoids have grown very large and fibrotic, requiring manual replacement after defecation, the results of treatment are less likely to be permanent. Coexisting conditions, such as mucocutaneous or external hemorrhoids, anal fissures, fistulas, suppurative cryptitis, and polyps, are indications for surgery, and in such cases injection is used only for palliative relief.

The equipment required is very simple: a good light, a medium-sized anal speculum, and a 2 c c syringe with 22 gauge spinal puncture needle are all that are needed.

Technic.—With the patient in the left Sims' position the well-lubricated forefinger is inserted, this gives the examiner important information as to the presence of feces within the lower rectum The presence of inflammatory induration or ex-

cessive sphincter spasm are contraindications for treatments; if there is induration from a previous injection, such a hemorrhoid should not be reinjected until the induration has subsided, in order to avoid slough. The anal speculum is then inserted its full length and under direct vision the obturator is slowly withdrawn, allowing the internal hemorrhoid to bulge into the speculum. The mucocutaneous line is identified; the perineal skin corresponding to the hemorrhoid in view is grasped between thumb and forefinger and pulled downward slightly, bringing the hemorrhoid into better view. The tip of the needle is then inserted into the center of the upper pole of the internal hemorrhoid and Quinuride is slowly injected. If the needle is left in place a few seconds, then rotated on its withdrawal, bleeding from needle puncture can be minimized; the remaining two internal hemorrhoids are similarly treated. It should be emphasized that there is no set dosage in cubic centimeters per injection, though an average of 0.33 c.c. per hemorrhoid or a total dose of 1 c.c. is injected at a treatment. Only those having wide experience should exceed these amounts. Actually the injection is made under close direct vision and the amount of solution injected is just sufficient to distend the hemorrhoid moderately. A slough can easily be produced by using too strong a solution or too large an amount, in which case the overdistended hemorrhoid will be seen to blanch immediately; slough will also follow an injection too superficially made. Production of a slough is not necessary for therapeutic effectiveness and, by exercise of diligent care, can be avoided. External hemorrhoids should never be treated by injection, and if the injection is made too close to the mucocutaneous juncture some of the solution may seep beneath the sensitive anal skin and produce pain. Protruding internal hemorrhoids are not injected until after they have first been replaced within the rectum. Injections are repeated at intervals of about two weeks and the hemorrhoids become progressively smaller with each injection. A slight induration in the hemorrhoid often follows each injection for a few days and if the induration persists, further treatment should be delayed. The patient should be informed that although both bleeding and protrusion will often cease following the first injection, treatments should be continued until maximum improvement has occurred. The number of treatments required depends largely on the size of the hemorrhoids. The average patient with medium-sized internal hemorrhoids will require from five to seven treatments. In most cases there will occur a mild reaction, coming on thirty minutes after the injection is made and lasting approximately one hour. This is described as an aching in the rectum or a feeling of weight or pressure there, with a desire to defecate even though the rectum is known to be entirely empty. This will be relieved by lying down and applying heat to the perineum. Defecation should be delayed for twelve to twenty-four hours after treatment, lest straining produce strangulation. If the hemorrhoids are large and protrude easily, the injection is made at a higher level than usual and a wad of cotton is applied to the anus, over which a "T-binder" is used to support the hemorrhoids within the rectum.

## *HEMORRHOIDECTOMY*

Hemorrhoidectomy is the treatment capable of producing complete and permanent cure for all types of hemorrhoids. A few surgeons consider hemorrhoidectomy a trivial procedure and in some institutions patients requiring this operation may be relegated to the most inexperienced member of the staff. The frequency with

which patients are seen, who, after having more than one hemorrhoidectomy, are still not relieved of their symptoms, is mute testimony to the tragic fallacy of this attitude. Failure to cure is not due to inherent difficulties in the procedure so much as to failure of the surgeon to recognize and eradicate all pathology present at the time or to complications arising from inadequate postoperative care. In the performance of a hemorrhoidectomy the surgeon must correct all pathology present, and often this includes such coincident entities as fissures, fistulas, and infected crypts. Either the dorsal lithotomy, the jackknife prone, or the left Sims' position may be used, as preferred by the operator Although they are not actually necessary, some benefit is usually derived by gentle massage and digital dilatation of the anus prior to surgery.

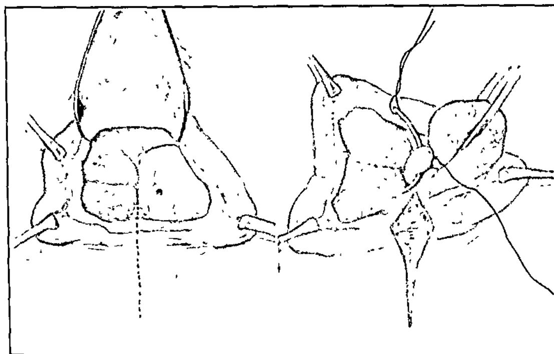


Fig 685. Fig. 686.

Fig 685 —Hemorrhoidectomy Internal hemorrhoids are exposed by traction of Allis forceps applied to external hemorrhoids

Fig 686 —Internal hemorrhoids are grasped with Allis forceps and pedicle is doubly suture-ligated with catgut Mucocutaneous border is incised posteriorly to afford relaxation and drainage of the wound.

This is done by inserting the two forefingers, additional fingers or bivalve instruments are never used. Forceful divulsion of sphincters is unnecessary and may result in permanent injury with incontinence of feces Since internal and external hemorrhoids almost always coincide in location, it is usually possible to remove them in such a way as to leave a strip of intact skin and mucous membrane between each wound, which acts as an island for the regeneration of epithelium to cover the defect. Wounds should be more or less smooth with tapered ends and should be extended slightly beyond the external border of the hemorrhoid into the perineal skin. Irregularities in the skin edges should be carefully trimmed away lest they undergo enlargement postoperatively and develop into so-called "hemorrhoidal tags."

**Ligature and Excision Technic.**—Allis forceps are applied to each of the three main external hemorrhoids, and downward and outward traction is made, which partially exteriorizes the internal hemorrhoids (Fig. 685). Care is exercised to apply

the forceps only to tissues whose *later excision is contemplated.* A medium-sized Sims' vaginal retractor is then inserted into the rectum, and with a scalpel an incision is made posteriorly through the lower rectal mucous membrane, anal and perineal skin, and subcutaneous tissues, *including a portion of the superficial external anal sphincter muscle.* The incision should be smooth, approximately 0.5 cm. deep and continued toward the coccyx for a distance of 2.5 to 3.75 cm. *Often* this incision will proceed directly through or very close to a hemorrhoid in the posterior commissure; the skin and mucosal edges of the incision, including adjacent hemorrhoids, crypts, and papillae, are excised with curved scissors. Bleeding vessels are *clamped and ligated with catgut; although the cut mucosal edge may be pulled* down slightly and clamped or sutured to the superficial fibers of the external sphincter, care is taken not to attach the mucosa to the skin for fear healing will result in the so-called moist anus, i.e., one lined with rectal mucosa rather than anal skin.

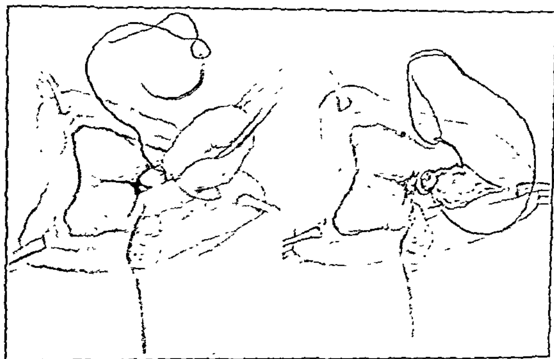


*Fig. 687.* *Fig. 688.*

Fig. 687.—Pedicle of the internal hemorrhoid has been doubly ligated and internal hemorrhoids will be excised along dotted line.

Fig. 688.—Running lockstitch from pedicle through submucosa for hemostasis: wound is not closed.

The internal hemorrhoid anteriorly is then picked up with an Allis forceps in such a way as to include the *maximum of varicose tissue and a minimum of mucosa.* A suture of No. 1 plain or 0 chromic catgut is then passed *around the superior pole* or pedicle of the internal hemorrhoid and ligated while an assistant makes downward traction on *the external hemorrhoid* (Fig. 686). The purpose of this suture is hemostasis of the branches of the superior hemorrhoidal artery, and it should include the mucosa and submucosa, but not the muscularis. A second suture ligature is placed about *the internal hemorrhoid at a point 0.5 cm. cephalad to the first* as an added precaution to prevent bleeding (Fig. 687). The internal hemorrhoid is then elliptically excised; bleeding vessels may *be clamped and ligated or caught in a running* suture from the original suture (Fig. 688). The right and left internal hemorrhoids are now similarly ligated and excised, and bleeding vessels are ligated, after

which the external hemorrhoids are trimmed away (Figs. 689 and 690). As has been said previously, although more than three or four hemorrhoids may be present, they can in practically every case be removed by including the additional hemorrhoids in the above-mentioned three groupings, to which a fourth hemorrhoid posteriorly may be added. Two small strips of petrolatum gauze or rubber dam drains are loosely inserted and removed twenty-four hours later; wounds are never packed.

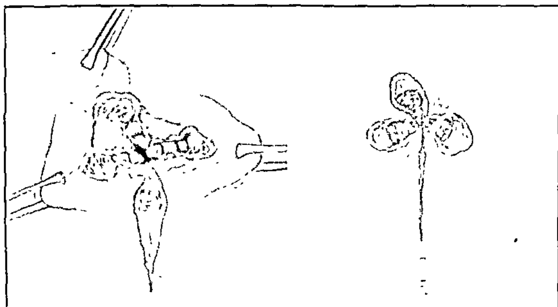


Fig 689. Fig. 690.

Figs 689 and 690.—After removal of internal hemorrhoids, external hemorrhoids are elliptically excised as shown by dotted line. Wounds are not sutured.

**Postoperative Care.**—Early ambulation is encouraged and liquids are given freely; patients operated upon in the morning may have soft diet for supper and general diet the following day. Demerol or Pantopon is administered hypodermically at four-hour intervals as necessary for pain. Local applications of boric acid ointment followed by continuous boric acid compresses to the wound with a warm-water bottle to maintain the heat, as well as hot Sitz baths three times daily, promote comfort and thereby greatly reduce the need for narcotics. Siblin or Metamucil is given by mouth twice daily for the first three to five days, and Sulfathaladine 1 or 1.5 Gm. four times daily for ten to fourteen days. The first bowel movement occurs forty-eight hours postoperatively; this is accomplished by giving 10 c c. of aromatic cascara the night before, followed by a soda water enema in the morning just before defecation is expected. The patient is asked to retain the clyster for a few minutes, then to expel it, trying in so far as possible to strain down and empty the bowel Fecal impaction with frequent small bowel movements and a feeling of heaviness or weight in the pelvis when on the feet may occur in the apprehensive patient who for fear of producing pain or bleeding will not strain and thereby fails to empty the rectum. Unless impaction is suspected, the finger is not inserted until the patient's first postoperative office visit, which is usually ten to eighteen days after operation.

**Fansler Operation for Prolapsing and Thrombotic Internal and External Hemorrhoids.**—The technic for this operation is as follows: "The sulcus dividing the squamous from the columnar epithelium is identified; one internal hemorrhoid

is grasped with an Allis forceps and an incision made at its lower margin. The edge of the corresponding external hemorrhoid is next grasped with an Allis forceps and dissected outward as far as normal skin, leaving a long flap of free anal mucosa and skin. Thrombotic internal hemorrhoids are excised until sphincters are exposed around the entire anal circumference. Bleeding vessels are ligated with 00 plain catgut. Rectal mucosa is allowed to retract and a Fansler operating speculum is inserted. Two sutures of 00 chromic catgut are passed through the outer margin of the skin flap and the needles left on the sutures. The rectal mucosa is grasped with Allis forceps at a point directly internal to the anal flap; the sutures in the anal flap are now passed through the rectal mucosa and a portion of the rectal wall representing the normal anorectal margin. The same process is repeated, using four or five flaps; the completed process shows a normal anus except for four or five lines of incision. Should a flap fail to adhere and evert, it is excised." (Fansler and Anderson.)

**St. Mark's Hospital Operation for Hemorrhoids.**—"With the patient in the lithotomy position the tag of skin corresponding with the hemorrhoid showing the greatest tendency to prolapse is grasped with dissecting forceps and drawn laterally away from the anus. Further traction on anal mucosa brings into view a longitudinal fold of rectal mucous membrane which is caught with artery forceps. An assistant retracts these with tension in the radial axis of the hemorrhoid as the two remaining hemorrhoids are delivered in a similar manner so that now all three pedicles are seen emerging radially in positions corresponding with the three primary hemorrhoids. With the tip of the index finger in the anal canal exerting steady pressure outward at the level of the subcutaneous external sphincter, the pedicle forceps and the skin forceps of the first hemorrhoid to be dissected are held in the palm of the hand and traction is exerted inward. With scissors incisions are made through the skin at the outer margin of the external hemorrhoidal plexus forming a 'V.' Incisions are continued through the corrugator cutis ani muscle until the circular band of the subcutaneous external sphincter is laid bare and the fibers of the longitudinal muscle may be seen. The pedicle containing branches of the superior hemorrhoidal artery and vein is now strongly retracted and tightly ligated with No. 16 woven silk. The two remaining hemorrhoids are similarly treated, after which excess tissues distal to the ligature are excised and edges trimmed to leave a flat open wound without redundant skin with at least 0.5 cm. mucous membrane and skin intact between each separate hemorrhoidal wound" (Milligan et al.)

## RECTAL PROLAPSE AND PROCIDENTIA

For practical purposes this interesting condition may be considered to be of two main types: first, prolapse of the rectal mucosa through the anus, and, second, procidentia, which is the protrusion of all coats of the rectal wall and, in some cases, other pelvic structures as well, through the anus. When internal hemorrhoids protrude, they, of course, bring with them their overlying mucosa which may easily be differentiated from true prolapse. Hemorrhoids appear as venous masses arranged in three or more longitudinal swellings with vertical sulci between them, while prolapsing mucosa is flatter and arranged in circular concentric folds. Not infrequently one sees some degree of prolapse of the rectal mucosa above and in connection with

large internal hemorrhoids. This redundant tissue is included in the excision of internal hemorrhoids at operation and requires no special technic for cure. Prolapsed rectal mucosa may be limited to one segment of the rectal wall and be small in size, perhaps protruding 2.5 cm. This type may be the result of injuries, or follow such surgery as deep fistulectomies or the Whitehead type of hemorrhoidectomy, and may rarely be seen in the aged arising spontaneously. In procidentia the protrusion consists of a single large mass protruding from the anal canal in which the overlying mucosa is arranged in circular folds and is usually of a darker red color than that of hemorrhoids; the mucosa is smooth and lacks the raspberry-like rough surface seen in hemorrhoids.

Procidentia involves the entire circumference of the rectum and will protrude outside the body from 2.5 to 12.5 cm in extreme cases involving the sigmoid and perhaps loops of small bowel or adnexa as well. Sometimes the anus will evert itself, in which case the rectal mucous membrane can be seen to join the anal skin directly; in other cases the prolapse begins at a higher level and the examining finger will reveal the presence of a sulcus between the prolapse and the anal wall. It is important to know whether the protrusion represents only redundant mucosa or if all coats of the bowel are present; this can best be decided by inserting the finger in the lumen of the rectum and palpating between forefinger and thumb the thickness of the tissues; a double layer of rectal wall including the muscularis is not difficult to differentiate from mucous membrane and submucosa only. The size of the protruding mass is deceptive, as some cases of prolapsed mucosa will be 5 cm. in diameter and 3.75 cm in length. Anything protruding further than this would most likely involve all coats of the bowel. Sometimes tumors protrude outside the rectum, pulling the mucosa of the bowel out of the anal canal.

The mucous membrane lining of the rectum is normally loosely attached to the muscular layer and may become more redundant, permitting it to prolapse through the anal canal. Procidentia must start as a hernia of the culdesac of Douglas anteriorly, with, also, weakness in lateral support of the rectal wall and stretching of the loose attachments to the hollow of the sacrum posteriorly It is most often seen in children and the aged; in the former, its descent is facilitated by the straightness of the rectum and pelvis; in the latter, emaciation with loss of supporting fat along with the loss of tone and the tissue relaxation of senility play a part. Chronic cough, constipation or diarrhea with constant straining may be the precipitating cause. When the patient is first seen, the sphincters are almost always relaxed and incompetent from overstretching; and in long-standing cases even the presence of the sphincters may be difficult to detect. The tone and competence of these muscles will often improve amazingly in infants if treatment is prompt, but if protrusion is allowed to continue over a long period, the sphincter function may be permanently lost In addition to the protruding mass, other signs will be soiling of underclothing by mucus, occasional bleeding on cleaning the parts, and soreness or chafing due to moisture.

**Injection Treatment.**—Injection treatment is most effective both in the prolapse of rectal mucosa and in procidentia in infants and children and should be given as soon as the prolapse is known, regardless of the age of the infant. It is doubtless true that some children will outgrow such weaknesses, but one should not delay therapy until the child is older, as each time the bowel protrudes it further stretches and tears the attachments of the rectum to supporting structures Not

only does this make each subsequent protrusion easier than the preceding, but also cure will be more difficult to obtain. Although injection therapy will lessen the prolapse in the aged, a lasting cure will not always be obtained without surgery. The technic for treatments of prolapse of the rectal mucosa is much the same as in the injection treatment of internal hemorrhoids and, of course, is not given until after the prolapse has been replaced within the body. For procidentia larger amounts of solution may be required and sometimes are more deeply placed. With the patient in the left Sims' position, a Brinkerhof anal speculum is inserted and the obturator is partially withdrawn. Quinuride is injected in the submucosa in three or four vertical columns, approximately 3.25 cm. high and located more or less equidistant about the circumference of the rectum. By injection such as this the rectal wall appears to become thicker and more rigid and the mucosa becomes adherent to the muscularis; however, the rate of cure in infants and children is very close to 100 per cent, and although several treatments are usually given it is very rare for protrusion to recur after the first injection. After treatment the buttocks are strapped together with adhesive tape for twelve hours and, if constipation occurs, intestinal lubricants are given by mouth.

Excision of Redundant Mucosa.—The lowest edge of the mucosa is dissected free of its cutaneous attachments, after which it is separated by blunt and sharp dissection from its attachment to the sphincter muscles. Redundant mucosa is pulled down and excised so that its cut edge is at a level even with the deep external sphincter muscle. The mucosa is now reattached to the superficial fibers of the external sphincter muscle by a running suture of catgut. If the entire circumference is involved, the anus may be more or less denuded and development of a postoperative stricture is likely to occur. To prevent this possibility, sliding grafts may be prepared by mobilizing one or more flaps of anal or perianal skin approximately 1.25 cm. wide and 3.75 cm. long, swinging the skin up into the anal canal and suturing it to the superficial fibers of the external sphincter muscle also, while leaving it attached at its base to the normal perineal skin.

Operations for Procidentia.—Cases of procidentia coming to surgery are not commonplace and few surgeons will have wide experience in handling them. Many ingenious and elaborate procedures have been devised to correct the condition, but the most sensible and satisfactory is the obliteration of the culdesac of Douglas as described by Moschcowitz in 1912 as follows:

". . . median abdominal incision, extending from the symphysis pubis to the umbilicus. After opening the abdomen the patient is placed in extreme Trendelenburg position. Every one with any experience knows the depths of the cul-de-sac of Douglas in a normal case, but he will be intensely surprised at its depth in cases of prolapse of the rectum: in fact, it extends several inches beyond the anus, as one can readily convince himself. The rectum is now pulled up and held taut. The subsequent steps vary according to the sex of the patient: I shall describe an operation in the female sex. Pagenstecher or silk sutures are passed circularly around the cul-de-sac of Douglas, and tied. The lowermost suture is placed about one inch above the inferior extremity of the cul-de-sac; similar sutures, six to eight in number, are passed at intervals, and persisted in as long as the peritoneum comes together until practically the entire pouch of Douglas is obliterated. It is advisable, and I always try to include in my suture the pelvic fascia, particularly that part

which covers the levator ani; how often I really succeed in doing this I am not in position to state. (Theoretically it would be better to split the peritoneum in the depth of the cul-de-sac, and to suture the fascia first. I have attempted to do so in one case, but found the procedure so difficult that I abandoned it.) When the sutures reach the region of the supravaginal portion of the cervix and body of the uterus, the sutures are anchored to these structures. When approaching the rectum, the sutures coming from the sides of the pelvis catch the serosa covering it, in firm and close stitches. This is done in order to prevent the possible formation of a hernia; in addition, these lateral sutures also materially aid in fixing the rectum to the sacrum and coccyx. There are two structures which should be avoided, namely, the ureters and internal iliac vessels. The former can be marked by introducing ureteral catheters; the pulsations of the latter serve as a guide; neither of these structures has thus far caused me any embarrassment. In older women the uterus is stitched to the anterior abdominal wall. No fixation of the intestine, viz., sigmoid flexure, is undertaken, as it is superfluous. Suture of the abdominal wall [is done] in layers."

## PRURITUS ANI

Pruritus ani is a disease of the anal and perianal skin which is characterized by itching, usually worse at night and often interfering with sleep. Many patients will have prolonged periods in which they are more or less symptom free, but such periods are followed by recurrence of the itching which may be so severe as to incapacitate the patient for work or diversion. The anal and perineal skin will show varying degrees of dermatitis corresponding with the severity of the symptoms. While there is disagreement among authorities as to the cause of the condition, agreement is general that the factors of excessive warmth and moisture play a part. Mycotic infections, allergies, neuroses, and secondary bacterial infection may produce these conditions.

Treatment aimed at the correction of such widely varying conditions is of course fundamentally a medical problem. The dermatologic axiom, "Soothe the acute and stimulate the chronic," is nowhere more applicable than in pruritus ani. Local applications of preparations containing local anesthetics may be of value temporarily but cannot be expected to effect a cure, and their prolonged use is the frequent cause of the development of a distressing drug dermatitis. Although careful cleanliness is extremely important, too frequent bathing should be avoided; tepid water and mild soaps should be used instead of hot water and stronger soaps. Since scratching aggravates the condition, an anesthetic of prolonged action injected beneath the skin will remove the desire to scratch temporarily while other measures are instituted to improve the local hygiene. This may readily be done in the office: the technic is to prepare the perianal skin with suitable antiseptic and inject 3 to 5 c.c. of procaine beneath the skin. This is followed by the injection of 1 to 1.5 c.c. of 0.25 or 0.5 per cent Diothane in the same areas; injection may be made in one or more quadrants or distributed about the anal circumference. Care is used not to inject the skin itself, nor to pool or place the injection too close to the skin, lest slough occur. After withdrawal of the needle the area injected is massaged to further equalize distribution of the solution. A small fluff of dry cotton placed within the anal canal will prove helpful in separating inflamed skin surfaces and absorbing irritating discharges. Roentgen ray therapy brings dramatic

relief in many cases, but often this proves to be only temporary, while sometimes it fails to relieve altogether. When internal hemorrhoids are present, injection treatment of them will often be of some benefit in pruritus by reducing anal moisture

Surgery is not advised for the pruritus itself, but in long-standing cases the anal skin undergoes irreversible changes due to chronic inflammation. These consist of thickening and hypertrophy of the skin with an underlying fibrosis of the subcutaneous tissues; the skin becomes thrown into numerous wrinkled and irregular folds or ridges which tend to radiate from the anal orifice. Between these folds are sulci which make cleaning of the parts both difficult and irritating. In some cases lasting relief will not be obtained until these folds of excess skin are excised Along with the development of these "hemorrhoidal skin tags" is a loss in the normal elasticity of the anal sphincters, which sometimes produces an anal stenosis, and this is frequently accompanied by anal fissures and hypertrophy of the anal papillae. The moisture from a prolapse of the rectal mucosa, or the discharge from a fistulous sinus will also contribute to the continuation of pruritus These are surgical conditions and for these appropriate surgery is indicated. The technics are given elsewhere in this chapter and do not differ except that in pruritic cases more skin is removed than would otherwise be necessary Undercutting of anal or perianal skin is not done.

When surgery is advised, it is wise to inform the patient that one is operating not for the pruritus per se but to remove other pathology that prevents attainment of cure, and that medical treatment will be necessary for a time after surgery.

## FOREIGN BODIES

Foreign bodies are of sufficiently infrequent occurrence to make them always interesting. Animal bones, splinters of wood, or toothbrush bristles may be unknowingly ingested, while in the mentally deranged a bizarre assortment of hardware may be deliberately swallowed.

Undoubtedly many foreign bodies pass through the entire digestive tract unnoticed, but occasionally a patient is seen who states that while defecating a sudden pain is felt as of something sticking him just inside the rectum. Further bowel movement was impossible and pain persisted. Such a history strongly suggests the likelihood of a foreign body; diagnosis can be made positive on the insertion of the examining finger into the rectum and palpation of a sharp spicule of bone, or other foreign body, imbedded in an anal crypt Care is used to prevent dislodging or deeper penetration of the foreign body by manipulation, but it is important to note its exact location. A local anesthetic agent is injected about it, a small Brinkerhof anal speculum is gently inserted and the obturator withdrawn so that the previously located foreign body can be visualized It is then grasped with a hemostat and withdrawn in the same direction as it pierced the bowel wall so as to free the foreign body with the minimum of trauma to the tissues. Such a puncture wound is very liable to infection and abscess formation; adequate dosage of antibiotics and local heat are indicated

Fecal impaction is perhaps the commonest foreign body encountered in the rectum. The symptoms are a feeling of weight or pressure in the rectum and the constant urge to defecate which is not relieved by the passage of frequent small bowel movements, these may be liquid feces passing around the fecal mass within

result of infection in the adjacent anal crypts. Occasionally a benign squamous polyp is formed as the result of hypertrophy; such polyps are usually single, but may be multiple, and in extreme cases are sometimes 2 5 cm in diameter and as much as 5 cm. in length. A polyp of this type would almost certainly protrude at stool and require digital replacement. Simple hypertrophied anal papillae are usually quite vascular and appear to the examiner as very red and sharply pointed toothlike projections about the anal circumference; when polypoid degeneration occurs, the papillae become blunted or rounded and appear white and avascular and on section contain quantities of fibrous tissue.

Anal crypts are small depressions or pockets, sometimes referred to as valves, just above and between the above-mentioned papillae. These structures were first described by Morgagni and are sometimes referred to as "crypts of Morgagni"; more recently, Tucker and Hellwig have emphasized the importance of the branched tubular glandlike structures beneath the anal skin and sometimes penetrating the sphincters which open into the depths of the crypts. Cryptitis and papillitis occur together and are accompanied by sphincter spasm which makes anorectal examination difficult and painful.

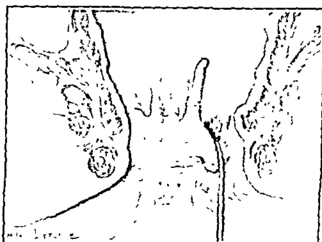


Fig. 691.—Hooked probe is shown in anal crypt with hypertrophy of adjacent anal papillae

The symptoms of cryptitis and papillitis are somewhat vague and are often overshadowed by the symptoms of accompanying conditions, such as fissure or hemorrhoids; sensations of warmth and irritation, or burning on defecation, and occasionally a feeling of incompleteness of bowel movement may be attributed to inflammation of crypts and papillae.

The treatment of this condition varies widely, if it should be encountered during the course of a routine examination in a patient having no symptoms, no treatment should be given. Although the presence of enlarged papillae and deep crypts means potential trouble of a serious nature, this is not always the case and many patients with such conditions are known to remain symptom-free indefinitely. Cryptitis and papillitis are frequently seen in those having other pathology as well, and, should operation be necessary for these, the crypts and papillae should be carefully excised at the same time, but the surgeon is not justified in advising surgery to every patient with an enlarged papilla Suppurative cryptitis, polypoid hypertrophy of the papillae, cryptitis with marked symptoms and muscle spasm are

indications for surgery. Sometimes it seems wise to remove a solitary crypt or papilla under local anesthesia in the office, but it would be poor judgment to attempt to remove multiple crypts or papilla except in the hospital.

Crypts may be satisfactorily removed by inserting a "hooked probe," bent at an angle of approximately 45 degrees, into the crypt and then lifting it up and away from the bowel wall; the tissues surrounding the probe are then excised with scissors in one bite (Fig. 691). Anal papillae occur at the base of internal hemorrhoids and during a hemorrhoidectomy are usually excised by simply being included in the hemorrhoidal tissues removed, or they may be picked up with a forceps and elliptically excised; care is taken to excise the entire papilla and not just the tip. A solitary polypoid papilla (benign squamous polyp) quite properly may be excised in the office under local anesthesia. The technic is to infiltrate the base of the polyp with local anesthetic agent, after which the polyp is grasped by a forceps held by an assistant and pulled away from the bowel wall (in many cases it may be pulled outside the anus). A cotton or linen ligature is then applied as close as possible to the base of the polyp; this may be facilitated by placing a clamp at the pedicle base, after which the ligature is applied above the clamp as the latter is released. The polyp is then excised a few millimeters distal to the ligature.

## ANAL FISSURE

Anal fissure is a longitudinal split or tear in the anal canal which is probably produced by the trauma of overdistention in the passage of a large, hard, or dry fecal mass through an anal canal whose normal elasticity has been impaired as the result of cryptic infection; bacterial invasion of the torn integument results in a chronic anal ulcer. A typical fissure averages 1 25 cm. in length and appears as a linear tear in the skin of the anal canal, the broken skin edges are somewhat thickened and indurated, and, when separated, exposed circular fibers of the sphincter muscle sometimes may be seen. Recent fissures may bleed easily and do not have the induration seen in chronic cases, nor are they usually accompanied by the extreme pain and sphincter spasm so characteristic of anal ulcer. Fissures are usually single and occur most often in the posterior commissure (approximately 85 per cent), or in the anterior midline (roughly 10 per cent), and are infrequently found laterally In about 30 per cent of cases the anal papillae immediately above the anal fissure will be found to be hypertrophied, and in addition there will be a small tag of thickened skin below the fissure and at the anal verge that is often referred to as a "sentinel pile," guarding the fissure above. "Sentinel pile" occurs in approximately 90 per cent of cases and is frequently the first evidence of fissure to be found on examination, it may readily be seen as the buttocks are pulled apart.

The presence of a fissure acts as an irritant to the sphincter muscle which is stimulated into strong spastic contraction, tightly closing the anal canal and producing a certain amount of local ischemia of the fissure, thereby delaying its healing and repair. In chronic cases varying amounts of fibrosis occur within and superficial to the sphincter mechanism as a result of bacterial infection in the crypts as well as in the fissure itself; this creates a narrowing of the anal lumen with loss of elasticity Pain is due in part to repeatedly tearing afresh the fissure or forcibly dilating the spastic sphincter at defecation and to fecal soiling of the lacerated anal canal with its exposed sensory nerve endings. Bacterial invasion sometimes results in abscess with undermining of the fissure and fistula formation.

Acute fissures or superficial lacerations of the anal canal will often heal readily by correction of constipation with intestinal lubricants, gentleness in cleansing the parts, and local applications of soothing and surface protective medicaments such as boric acid or Diothane ointments.

**Injection Treatments.**—Chronic fissures or anal ulcers will not usually respond to the simple measures listed above, but most will be at least temporarily relieved and some apparently cured by the injection of one of the long-lasting anesthetic agents such as Diothane solution or one of the oil preparations A satisfactory technic is to infiltrate beneath the fissure and into the sphincters posteriorly and laterally with approximately 6 c.c. of 1:1,000 Nupercaine solution followed by the injection of 1 to 1.5 c.c. of 0.5 per cent Diothane solution. The sphincters are then vigorously massaged with the forefinger and dilated by insertion of a large anoscope. Intestinal lubricants and local applications of boric acid ointment are used until healing is complete. Injection should not be attempted where undermining or suppuration complicate the fissure.

Surgical excision of anal fissures can usually be expected to produce complete and permanent cure. The anesthetized patient is placed in suitable position and the anus is dilated to admit two fingers; a Sims' vaginal retractor or other suitable speculum is inserted and the fissure is located. An incision parallel to and approximately 1 cm. lateral to the fissure is made with scalpel, starting in the lower rectum just above the pectinate line and continued downward through the postanal skin for a distance of 2.5 cm. or more behind the anus and about 0.5 cm. in depth, passing through the anal skin, subcutaneous tissues, and a portion of the superficial external sphincter muscle. The fissure is then elliptically excised with scissors, and a strip of anal skin 2 to 3 cm. wide and including the sentinel pile, as well as one or more crypts and papillae, are removed The resulting wound presents the exposed sphincters and should be made smooth. Sometimes a few additional fibers of the muscle will have to be cut in order to smooth out irregularities in the wound surface. Bleeding vessels are clamped and ligated with plain catgut; no attempt is made to close the wound, and a strip of petrolatum gauze or rubber dam is inserted into the anal canal to be removed twenty-four hours later. Postoperative care is exactly the same as that given for hemorrhoidectomy.

## *ANAL STENOSIS*

By anal stenosis is meant the gradual loss of elasticity and reduction in caliber of the anal canal by infiltration of scar tissue resulting from chronic anal infections, such as cryptitis, papillitis, pruritus ani, and anal fissures which are very often multiple, the habitual use of cathartics also plays a role in production of stenosis. Faulty surgical technics as well as wound infection are usually responsible for postoperative anal strictures.

Inspection reveals scars of chronic infection, with indurated and somewhat irregular and relatively avascular "skin tags fore and aft"; the orifice looks small and unyielding. In many instances anesthesia must precede insertion of the examining finger, and as this is done the inelastic and scarred tissues are frequently felt and observed to split in one or more places. At other times the forefinger may be admitted without break in the integument, but the examiner is impressed with the fibrous nature of the anal canal and its inelasticity

In a great many instances temporary relief follows simple dilatation under local anesthesia in the office, and as the condition has its greatest incidence in the aged, it is often wise at least to try this in cases uncomplicated by fissures, polyps, or fistulas, before resorting to surgery.

In cases not relieved by dilatation or in which such complications as listed above are present, surgery is advised. With the anesthetized patient in suitable position, the finger is inserted and the muscles are massaged and dilated; the other forefinger is then inserted and the two fingers are pulled apart to the equivalent of a three-finger dilatation. Restraint and judgment are, of course, necessary as there is very great danger that too wide a divulsion might result in incontinence; use of fingers is far safer than the employment of metal instruments for this purpose. Fissures, fistulas, polyps, crypts, papillae, or hemorrhoids which coexist are, of course, excised, and it is rare not to find several of these conditions present. Usually surgery includes vertical incisions through the skin, subcutaneous tissues, and a few fibers of the superficial external sphincter muscles at both the anterior and posterior commissures; this is continued out through the perineal skin for 2.5 cm. anteriorly and approximately 5 cm posteriorly. Postoperative care is the same as for hemorrhoidectomy.

## ABSCESSES

Abscesses frequently occur about the anus and rectum. In most cases they develop from infection in the anal crypts and for this reason they differ somewhat from abscesses elsewhere in the body. A high percentage of them are followed by fistulas The anorectum is surrounded by five important anatomical spaces which tend to limit the spread of infection to the space involved. Involvement of more than one space is frequently the result of delay in establishing adequate surgical drainage; it may also be explained on the basis of low tissue resistance as in diabetes, but it very rarely may begin as a diffuse inflammatory process. Below the levator ani muscle are the two ischiorectal spaces, while above this important structure are the right and left supralevator spaces and the retrorectal space. Although, occasionally, simple furuncles develop from infection within the hair follicles of the perianal skin and are not followed by fistulas, most abscesses in this location originate as a cryptitis developing deep within the tissues and thus may be differentiated from those having their inception in the integument.

Ischiorectal abscesses are encountered with far greater frequency than any other variety. Since the process originates in the anal crypt area and gradually spreads into the rather large ischiorectal space, the symptoms and signs vary with the extent of spread If seen early, pain, swelling, and tenderness will be found close to the sphincter muscles, later, as suppuration progresses, the ischiorectal space will become so distended and tense that pain is almost intolerable and the patient is unable to walk or sit. A glance will show one buttock to be much larger than the other, with marked redness and warmth of the involved side. Coughing aggravates the pain, but defecation can be accomplished fairly well If drainage is not established by incision or spontaneous rupture, the tension within the abscess increases and the inflammatory process breaks through to the opposite side at either the anterior or the posterior commissure; if it spreads anteriorly, urinary retention may develop and add to the patient's misery. With large abscesses the constitu-

tional symptoms of chills, fever, profound toxemia, and leukocytosis are manifest, as well as fluctuation, which may not be discernible in smaller ones.

Treatment is immediate incision and drainage, which will prevent the destruction of tissue and spare the patient much needless suffering. Waiting for the abscess to reach the skin surface or "point" is an inexcusable error of judgment. Antibiotics and sulfonamides may be of definite value in the stage of cellulitis, but will be of little benefit when pus has formed, and are never a substitute for drainage The diagnosis is not always easy but should be suspected in every case of progressive pain and inflammatory swelling of seventy-two hours' duration or more. Cases of suspected abscess should be kept under close observation as the physical findings will sometimes change markedly in a few hours' time. Care should always be used not to incise an area of cellulitis prior to the formation of pus, and, if some doubt remains, aspiration may be attempted. The skin overlying the mass is infiltrated with local anesthesia, and with the forefinger in the rectum as a guide the needle is directed into the center of the mass and pus is aspirated with a small syringe. Once a drop of pus is seen, incision and drainage are mandatory; failure to obtain pus may mean that the needle was not properly placed to tap pus actually present, or the pus may have been too thick for aspiration through the needle; if the latter is suspected, a few drops of Novocain may be injected to clear the needle, and gentle suction on the syringe is more successful than strong suction.

For drainage of an ischiorectal abscess some physicians hospitalize the patient as an acute surgical emergency and under spinal or general anesthesia incise the abscess and remove the involved crypt at the same time. This procedure is dangerous from the standpoint of possible permanent injury to the sphincter muscle which may not be recognized due to inflammatory displacement and distortion. The inflammatory reaction in the tissues may render identification and probing of the involved crypts difficult; extensive surgery performed on such tissues may be followed by dense and mutilating cicatrices. Incision and drainage of ischiorectal abscesses is a satisfactory procedure to perform in the office under local anesthesia, and relief is immediate. One should always inform the patient that a fistula may follow the abscess and will require surgery later

With the patient in the left Sims' position, the skin of the perineum and buttocks overlying the abscess is prepared and infiltrated with a local anesthetic in a linear manner which the incision will follow, the anesthetic is also fanned out to some extent laterally and in the subcutaneous tissues if the abscess lies deeply. In abscesses close to the sphincters the incision should be parallel to the sphincter fibers; otherwise, an incision radial to the anus is then made through the skin and overlying tissues into the abscess cavity and extended to assure free drainage. First one, then the other, edge of the wound is grasped with forceps, and a wedge of skin and subcutaneous tissue is excised elliptically. This in effect removes the dome of skin and other tissues overlying the abscess and provides free drainage, no drains are used Often the incision will have to pass through 2 or 3 cm. of more or less normal tissue to reach the abscess cavity, in such cases a finger in the rectum is a useful and safe guide. Care is taken in making the incision not to include the sphincters.

Retrorectal abscesses are also fairly common, and the diagnosis, signs, and symptoms are less obvious than the ischiorectal variety Inspection frequently fails to find visible swelling in the posterior perineum, and digital examination will occa-

sionally not reveal abscesses of fairly large size, though in most cases the fluctuant mass can be felt posteriorly between thumb and forefinger on digital examination. In doubtful cases aspiration should precede incision through the postanal skin, using the same technic as described for ischiorectal abscesses.

Supralevator or pelvirectal abscesses are fortunately uncommon, as they are difficult both to diagnose and to treat. The local signs are usually more or less entirely lacking until fairly late; chills, fever, leukocytosis, and toxemia are, as a rule, the presenting complaints, followed by vague lower abdominal pain gradually settling in the rectal area. There may be a feeling of heaviness or weight in the pelvis With the examining finger in the rectum a fluctuant mass can usually be felt to one side of the rectum and well above the sphincters. Drainage should not be attempted except in the hospital and then usually under spinal or general anesthesia Incision should not be made through the rectal wall or a high fistula may result, but instead the incision is made through the perineum lateral to the anus, 2.5 cm. or more away from the anal verge, and must be of adequate length. A closed Kelly forceps is then inserted into the wound and forced upward and through the levator muscle and into the center of the abscess, the finger in the rectum again being used as a guide; the forceps is then opened and this is followed by a gush of pus. The opening through the levator muscle is now widely dilated and a cigarette drain is inserted. In a great many cases no cryptic connection can be found and the sinus heals slowly; where cryptic origin is found, it is usually wise to remove this as a subsequent procedure.

Rarely an abscess in the rectal submucosa is encountered, patients complain of pain, heaviness, and a constant desire to defecate. Again the diagnosis is made by feeling a soft fluctuant mass just beneath the mucosa. Incision, without anesthesia, through the rectal mucosa is followed by uneventful healing Subcutaneous or subcryptic abscesses are sometimes encountered and usually rupture spontaneously and early, giving rise to the so-called blind internal fistulas to be described later. Where incision is necessary, it can easily be done in the office under local anesthesia.

## ANAL FISTULA

By fistula is meant a false passage or infected tract leading from the anus to the skin of the perineum or to some other hollow viscus, usually having an internal opening in an anal crypt and a secondary opening in the skin. Such a fistula would be termed a complete fistula and would almost certainly be preceded by an abscess, though sometimes patients are found to have fistulas who deny ever having had an abscess or symptoms of one. Until quite recently it was taught that lasting cure was dependent upon complete removal of the sinus tract. It was also erroneously thought that the presence of fistula was conclusive evidence of tuberculosis; we now know that less than 2 per cent of all fistulas are of tuberculous origin If the patient's general condition is good, such fistulas will heal under the same management as those of simple pyogenic origin.

Diagnosis is made by finding on inspection of the perineum a sinus, usually with a raised tuft of granulation tissue near the anus from which pus can be expressed. A probe inserted in the sinus would generally lead toward the anus; very often a cord of indurated tissues beneath the skin can be palpated, leading from the external sinus opening to the anus, but this is not always a straight and direct

the suspected crypt as well as those on either side of it are excised. Every effort should be made to avoid injury to the sphincters during surgery, but sometimes a fistulous sinus will be found to penetrate the muscle and it will be necessary to incise a portion of the muscle in order to cure the fistula. Of course the incision should be no deeper than absolutely necessary, and this is a great advantage of the incision and drainage technic over the older method of excision. The muscle is never cut except at right angles to the direction of its fibers. Complete severance of the external sphincters will be followed by fecal incontinence, but continence will be preserved if a small portion of the deep external sphincters can be spared. Where the internal opening is found to be above the entire sphincter mechanism, a cure may sometimes be effected by use of the seton. In this procedure the incision is made down to a probe from the external sinus to the sphincter muscle just as in any other case; a second incision is made down to the probe from the internal opening and including a portion of the deeper sphincters, but not entirely through it. A seton of strong linen or cotton is then passed through the remaining unopened portion of the fistula and around the remaining portions of the sphincters and loosely knotted. The wound is allowed to heal for about two weeks, then more of the deeper portion of the sphincters is incised, until finally the last of the tissues included in the seton are severed. In this way the intact portion of the sphincters will prevent the wide retraction of the cut muscles. Fistulotomy wounds are left open and drains of petrolatum gauze or rubber dam are loosely inserted for the first twenty-four hours; wounds are never packed, nor closed by suture.

## BLAISDELL METHOD OF REPAIR OF THE INCONTINENT SPHINCTER ANI

Total inability to control the passage of gas or feces is fortunately very rarely encountered, but partial loss of control, as manifested by fecal soiling and leakage of gas, is more common than generally realized. The tragic consequences of sphincter impairment make knowledge of a reliable method for its repair very necessary. Injury to the sphincter ani muscle may come as an obstetrical accident or may follow such surgical procedures as incision and drainage of perirectal abscesses, fistulectomy, too deep an incision in fissurectomy, or forceful divulsion of the sphincters preliminary to surgery on the anus and rectum. Rarely incontinence follows impalement or anal laceration sustained in falls or other accidents, and once in a great while the sphincters must be cut in order to effect the cure of a deep fistula Although inefficiency of the sphincter muscles is of paramount importance in the creation of incontinence, anal deformity is often a contributing factor of importance as well. Usually this will be in the form of a cleft or sulcus in the anal wall containing the scar of a previous wound; prolapse of rectal mucosa above the scar is not uncommon.

Blaisdell has in a series of articles since 1939 gradually evolved a simple method of restoring continence with the very great advantage that in the event of failure the patient will at least not be made worse.

**Technic of the Blaisdell Inversion Operation.**—"An incision is made through the skin delineating the outer edge of the pocket defect, and the surface tissue covering the latter is carefully dissected free. [Fig. 692, *A*.] Of inestimable value for this is a Jones tonsil knife, specially honed and stropped, to bring the curved end as

well as the sides to razor sharpness. Preservation of this tissue intact is important, for even minute buttonholing may transform the operative dissection into a fistulous wound.

"The full body of the sphincter is seized within the bite of an Allis forceps, the teeth paralleling the fibers and placed exactly at the periphery [Fig. 692, *B*], a little above the first incision. A second incision is made close to the Allis forceps along the periphery of the sphincter, freeing a flap containing one end of the muscle and joining the original incision. The cut should go as deeply as possible without penetration of the intra-anal surface of the flap, which would be disastrous. A third incision in similar manner frees a muscle-bearing flap on the other side of the defect.

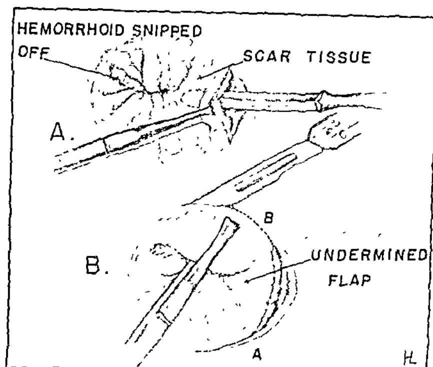



Fig 692 —Inversion operation of Blaisdell *A*, First incision and freeing of skin over scar are shown Preservation of this flap prevents a fistulous wound, it is important for the same reason not to buttonhole it. *B*, The whole thickness of external sphincter is grasped in Allis forceps at A and B in turn, and peripheral circular incisions are made to join original incision *C* and *D*, Placing of first steel wire stitch over buttons and diagram of result achieved This stitch would be more readily tightened to position, and more effective, if anchored at *x*, as shown by dotted line Otherwise it tends to slip over the side in direction of the arrow. If this stitch is correctly placed, the buttons should disappear into the anus *E* and *F*, Second steel suture placed. Ineffective or constricting sutures are then adjusted or replaced (Courtesy Dr Paul C. Blaisdell )

"The two flaps are then united by a mattress suture with the peripherally freshened surfaces in apposition. [Fig 692, *C* and *D* ] The two ends of the muscle and other intervening tissue are invaginated toward the center of the anus to fill the defect. Progressive trial sutures of absorbable and more easily handled material may or may not precede the final steel suture to determine the proper balance of three variable factors involved, viz., amount of invaginated tissue, final restored muscle continence, and wound tension The latter can be lessened even after final suture, if found to be desirable, by extending the peripheral incisions further, but the effect of this on final continence must also be kept in mind

"It is important to prevent cutting of the tissue by the steel suture over a prolonged period and for this purpose both ends of all mattress sutures are secured

over baby buttons available at the dime store. We are confident that this detail of technic is a necessity and wish to emphasize that no confidence whatever is placed in anything but wire mattress sutures over buttons for any plastic anal surgery. Large substantial bites are likewise essential. A diamond-shaped defect will then be found to have formed lateral to the sutured flaps. One or more wire retention sutures, also with buttons, are placed here to relieve tension on the muscle suture. [Fig. 692, *E* and *F*.] The wound is not completely closed and, indeed, the skin edges should purposely be prevented from union before healing of the deeper tissue has taken place.

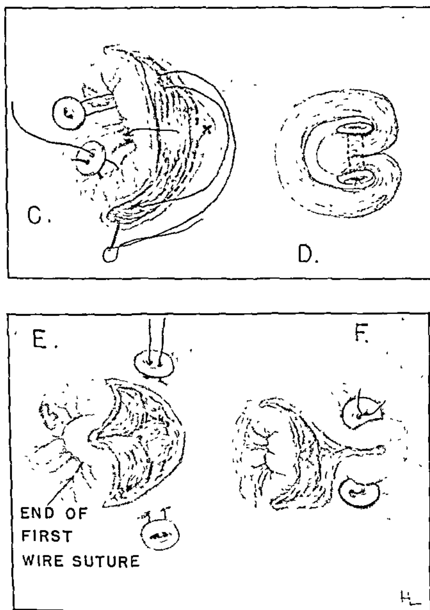



Fig 692, *C-F* (*For legend see opposite page.*)

"Experience is required to assess the proper tension correctly and even buttons will easily slough clear through from pressure necrosis as one tends to err on the side of excessive tension. Surgical technic itself, no matter how meticulous, may prove futile unless maximum protection is afforded the sutured sphincter. In addition to constant surveillance and certitude of suture effectiveness this is insured

principally by preoperative and postoperative measures to defer bowel movements after surgery, to maintain soft consistency for some time, and above all to prevent impaction and sudden explosive evacuations" (Blaisdell, 1940).

## BENIGN TUMORS

Sigmoidoscopic examination of every patient would doubtless reward the examiner by the discovery of many unsuspected lesions, the majority of which would be nonmalignant tumors, while many would be classified as precancerous, and certainly some asymptomatic malignancies would be revealed. Such a program may not at present be practical, but the fact is that tumors of the anus and rectum are of common occurrence and the wise physician must keep this possibility constantly in mind regardless of the age of the patient. Every tumor growth or suspicious ulceration should be biopsied; in the anus 1 or 2 c.c. of local anesthetic agent will be necessary for this, while none is required for lesions situated above the anus. Usually one specimen is sufficient, but if there is any question that the tissue biopsied is not representative, several bites of tissue should be taken from scattered areas of the growth. The disadvantages to the taking of biopsy specimens are: the not very great danger of perforation; bleeding which is generally trivial, but on occasion may become embarrassing; and the opening of vascular channels through which the spread of malignant processes may be facilitated. Despite these drawbacks, free use of pathologic study is essential, and until proved otherwise every growth should be considered malignant.

Benign squamous anal polyps have been described under the heading, Papillitis.

Condylomata acuminata, erroneously called venereal warts, are fairly common about the anus and perineum as well as the genitalia. These are not true neoplasms but appear as multiple wartlike growths, probably of viral origin, which make the skin surface extremely irregular and difficult to clean. A certain amount of moisture and maceration is usually present, with itching a prominent symptom.

*Treatment:* Local application of 25 per cent podophyllin in alcohol or mineral oil should always be tried first. In favorable cases the soft condyloma will become escharotic and after a day or two disintegrate dramatically. Occasionally condyloma will be seen that are dry and cornified and do not respond to the podophyllin; these should be removed surgically or with the electric cautery under local anesthesia and usually as an office procedure. The tendency for such warts to recur after removal indicates that an adequate follow-up will be necessary to achieve a lasting cure. Podophyllin is quite irritating; it should be sparingly used and should be removed by warm soapy bathing after one hour, followed by local application of a soothing ointment for a few days.

Villous papilloma is generally found in the rectum. While infrequently encountered, it has usually attained large size when first seen. It is composed of innumerable soft fingerlike projections which are so extremely fragile that a digital examination will often dislodge a few fragments. Villous tumors are most often sessile, though they are sometimes attached to a broad pedicle and are accompanied by the secretion of copious quantities of mucus with scant bleeding. While this is a benign tumor, malignant degeneration has been observed to occur in certain instances, and most authors advise radical resection. Complete local destruction is difficult and tedious but will, in most instances, be followed by lasting cure.

*Technic of local excision through the anus:* Spinal anesthesia is preferred because of the greater relaxation obtained Often it is possible to deliver through the anus tumors attached fairly high in the rectum; this, of course, greatly facilitates their removal. The bulk of the tumor with its pedicle or attached mucosa is ligated and transfixed with catgut and excised. All remaining tumor is thoroughly destroyed with the electric cautery. Postoperative care is aimed at preventing wound infection, and for this purpose Sulfathaladine is given by mouth for about two weeks. The area is carefully inspected through the sigmoidoscope at intervals, and any evidence of beginning recurrence is immediately destroyed with the electric cautery. The patient should be seen once or twice annually for several years for checkup to prevent the possibility of recurrence.

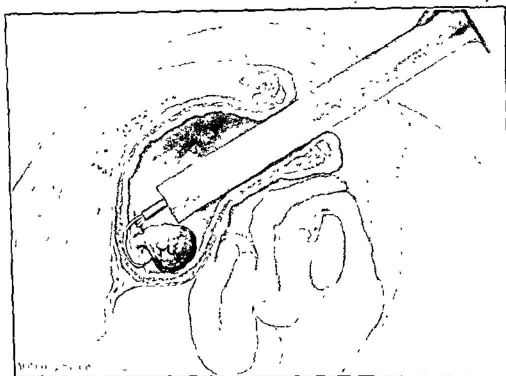


Fig 693 —Sigmoidoscopic removal of pedunculated rectal polyps, including mucosal base, with the electric snare. Bleeding is prevented by first using a coagulating current before switching to the cutting current

Adenoma or adenomatous polyp is one of the most common neoplasms and occurs at all ages, being found frequently in infancy and childhood. Adenomas vary from a few millimeters to several inches in diameter, may be single or multiple, and are usually pedunculated, but occasionally are sessile. They protrude into the lumen of the bowel and do not invade the basement membrane, though they do have a tendency to undergo malignant degeneration. Bleeding is the most common symptom of adenoma and at times may be fairly free, though it is usually scant and may be altogether lacking While the vast majority of adenomas are found by use of the sigmoidoscope, some are palpated by the examining finger, and rarely a polyp on a long pedicle will actually protrude through the anus. When an adenoma is found, further search for the possible presence of others should be carried out since they are often multiple and also because they are frequently found associated with malignancies. The diagnosis of polyps beyond the limits of the sigmoidoscope is best made by barium enema x-ray study, using the air contrast technic. Due to

the possibility of error in interpretation of x-rays, colotomy is not advised unless a second study after a suitable interval confirms the diagnosis.

*Treatment:* Since adenomas are prone to malignant degeneration, their prompt discovery and complete removal or destruction in situ is very important. In a great many instances this may be done safely and satisfactorily *through the sigmoidoscope* without anesthesia. Skill and care in the handling of instruments will prevent perforation and control hemorrhage. Adenomas of 3 mm. or less in diameter are thoroughly destroyed with the electric cauterodyne. Growths larger than this and including small sessile growths can often be grasped in the noose of an electric snare and compressed as the base is coagulated with a slow current, later switching to the cutting current for final removal (Fig. 693). It is, of course, very important to destroy thoroughly the pedicle or base of the adenoma to prevent recurrence, and it is also important to preserve the polyp for pathologic study and final diagnosis. Large polyps should be biopsied prior to removal, but in the small variety a good biopsy specimen often completely removes the growth and it is wise to record carefully the location of the polyp site, as more radical measures will be indicated if the pathologist finds evidence of malignant degeneration. Occasionally adenomas are too large to enter the loop of the snare but are removed bit by bit with the electric snare until entirely destroyed. Needless to say, such a procedure, while avoiding an abdominal operation, runs an added risk of hemorrhage which may be difficult to control. Usually large sessile adenomas are best removed by resection and anastomosis or by proctosigmoidectomy. In every case a careful periodic follow-up is a wise precaution to detect and destroy any recurrence that may develop.

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## WOUNDS OF THE LIVER

The liver may be damaged by blunt trauma and stab or gunshot wounds. The primary problem is the control of hemorrhage, but badly damaged and devitalized liver should be removed. Suturing of the wound is rarely possible because the sutures usually cut through. Packing of the wound with gauze has been resorted to in the past, but this sometimes may result in secondary hemorrhage due to infection and necrosis of liver tissue surrounding the wound. The packing, if used, is brought out through a stab wound and is removed on the eighth day. Mortality and morbidity have been reduced in recent years by controlling hemorrhage with either Gelfoam sponges or Oxycel gauze and thrombin and leaving the laceration open. When this is done, the abdominal cavity is closed without drainage.

## ABSCESSES OF THE LIVER

Hepatic abscesses requiring surgical management most commonly are either pyogenic or amebic in origin. The treatment of pyogenic abscesses is by open surgical drainage, while the treatment of amebic abscesses is usually conservative. Amebic abscesses are commonly seen in tropical countries but have been more frequently seen in the United States following the service of so many men and women in endemically infected areas during World War II. We are indebted to Ochsner and DeBakey for much of our knowledge in the treatment of this condition.

The diagnosis of amebic abscess is made on the basis of history, or the finding of ova in the stools or in the aspirated contents of the abscess Emetine hydrochloride should be started at once in 1 grain doses subcutaneously daily until a total of 6 to 10 grains is given. Response may be satisfactory provided suppuration has not been to
place.
tion of the abscess.

### *Aspiration of Liver Abscess*

If the abscess is located anteriorly, the aspirating needle is inserted at a point beneath the lower costal margin 5 to 6 cm. from the midline in the direction of the abscess until pus is encountered Posteriorly located abscesses are aspirated by inserting the needle below the mid-point of the twelfth rib and directing it anteriorly and superiorly. Aspiration may also be done through the ninth or tenth intercostal space in the anterior axillary line for laterally located abscesses. All the pus possible is removed, but repeated aspiration may be necessary. Rigid aseptic technic must be practiced to prevent secondary infection of the cavity with pyogenic organisms. If the abscess is found to be secondarily infected with pyogenic organisms, open drainage is indicated. Although the mortality with open drainage of amebic abscesses is higher than with aspiration, open drainage occasionally may be necessary if the patient continues to run a septic course in spite of emetine therapy and repeated aspiration.

### Drainage of Liver Abscess

Pyogenic hepatic abscesses and secondarily infected amebic abscesses are drained in the same manner as subphrenic abscesses, depending on their anatomical location in the liver. Anterior abscesses are approached through a right subcostal

incision extending down to the peritoneum. If there is sufficient reaction about the abscess, the peritoneal surfaces are adherent and the abscess can be drained at this time without contaminating the peritoneal cavity. Penrose drains are placed in the cavity and brought out through the incision. Drainage must be maintained until it is certain that the cavity is obliterated.

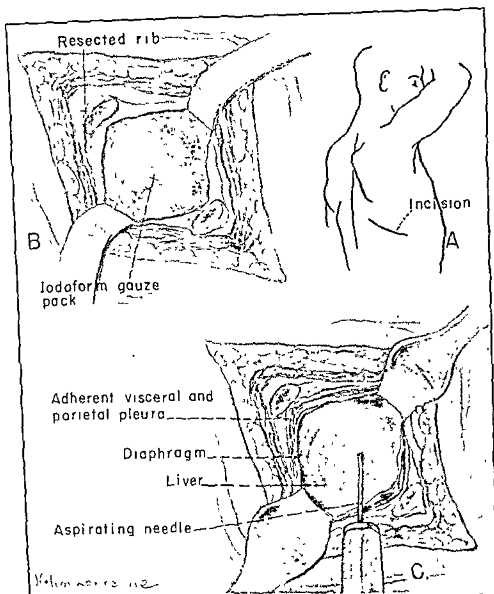



Fig 694.—Drainage of liver abscess transpleurally. *A*, Incision is made over the ninth rib *B*, Portion of the ninth rib has been resected and iodoform gauze packed against the pleura. *C*, Several days later the packing is removed and the abscess cavity aspirated.

Abscesses located posteriorly can be drained either transpleurally in two stages or extrapleurally in one stage. In the transpleural approach a segment of the eighth or ninth right rib is resected and the pleura exposed (Fig. 694). Iodoform gauze is packed against the pleura to produce reaction and adherence of the pleural surfaces to each other. Five or six days later the liver is exposed by an incision through the two adherent pleural surfaces and the diaphragm The abscess is first located by using an aspiration needle, after which the liver overlying it is incised, preferably with the electrosurgical knife, to establish drainage. Penrose drains are placed in the cavity and brought out through the incision. Drainage is maintained until it is certain the cavity has been obliterated. The one-stage extrapleural and

extraperitoneal approach as advocated by Ochsner is described in detail under Drainage of Subphrenic Abscess. A segment of the twelfth rib posteriorly is resected and a transverse incision is made through the rib bed and the insertion of the diaphragm to expose the liver retroperitoneally.

## SUBPHRENIC ABSCESS

Subphrenic infections usually result from intra-abdominal pathology, such as a suppurative appendix or gall bladder, a perforated peptic ulcer of the duodenum or stomach, or a suppurative infection of the liver. Spread is usually by direct extension but rarely may be through the lymphatic or blood stream. A majority of such

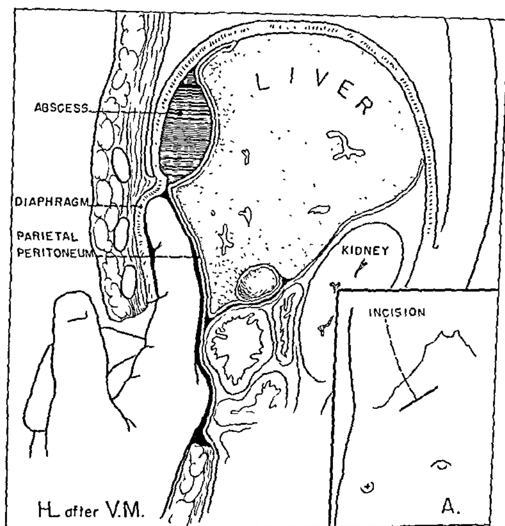



Fig 695.—Extraperitoneal drainage of subphrenic abscess in right anterior space. The finger separates the liver from the parietal peritoneum and the abscess is opened by blunt dissection *A*, Position of incision.

infections resolve under conservative therapy. Such therapy consists of antibiotics, transfusions of whole blood when necessary, and diathermy. Surgical drainage is necessary if frank suppuration occurs. Careful localization of the infection is essential before drainage is attempted because of the danger of contaminating the peritoneal or pleural cavities by an improper approach.

Infections both above and below the liver are included in the subphrenic group. Between the diaphragm and the liver on the right are two spaces, the right posterior

superior and the right anterior superior; while on the left there is one space, the left superior. Below the liver on the right there is only one space, the right inferior, which lies between the liver and the transverse colon. The falciform ligament separates the right inferior from two left inferior spaces. One left inferior space lies anterior to the stomach and the gastrocolic and gastrohepatic omenta, and the other in the lesser peritoneal sac posterior to these structures. The left anterior-inferior space is limited below by the transverse colon.

## Drainage of Subphrenic Abscess

Anterior space abscesses are drained through a subcostal incision. The anterior rectus sheath is opened obliquely and the rectus muscle is split. If the abscess involves an inferior space and has resulted in sufficient reaction between it and the

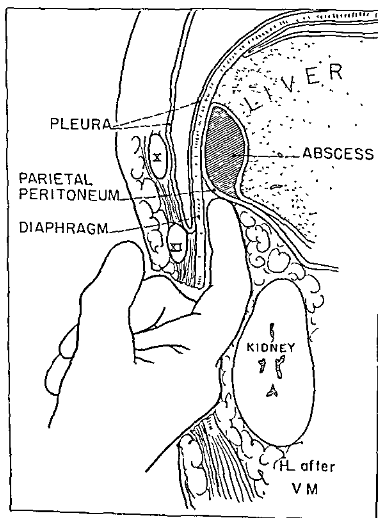



Fig 696.—Drainage of subphrenic abscess in right posterior space. The parietal peritoneum is separated from the diaphragm by blunt dissection and the abscess is opened.

parietal peritoneum, the cavity can be entered directly through the overlying peritoneum without danger of contamination. If it is in the left superior or right anterior superior areas, the peritoneum is not opened but is bluntly separated from the anterior abdominal wall and the undersurface of the diaphragm until the abscess is reached (Fig. 695). The overlying peritoneum is then broken through and drainage is established Penrose drains are inserted for drainage.

There are two methods for approaching posterior superior abscesses on the right. One is by means of a two-stage transpleural procedure and the other through the extrapleural and extraperitoneal one-stage approach advocated by Ochsner (Fig. 696).

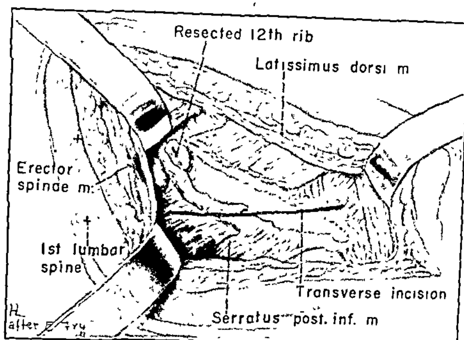



Fig 697.—Extraperitoneal drainage of subphrenic abscess in right posterior superior space. A portion of the twelfth rib has been resected.

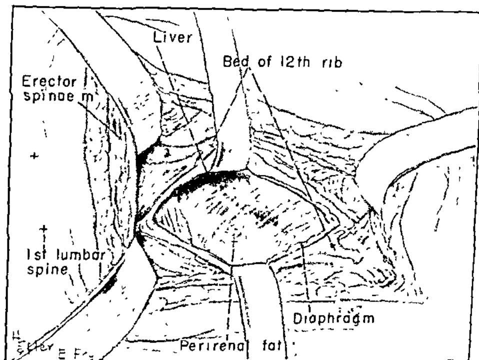



Fig 698 —Extraperitoneal drainage of subphrenic abscess in right posterior superior space The diaphragm and perirenal fat have been exposed and the abscess will be opened

In the transpleural approach a segment of the eighth or ninth rib posteriorly is resected subperiosteally and the pleura is exposed, as is described in drainage of posteriorly located liver abscess (Fig. 694) Iodoform gauze is packed against the pleura to encourage the formation of adhesions between the two pleural surfaces.

grasps the gall bladder just above the cystic duct to aid in the exposure of the cystic duct and artery (Fig. 699). The peritoneum over the ducts is divided and the cystic duct is exposed. It is isolated and its relationship to the common duct is carefully determined (Fig. 700).

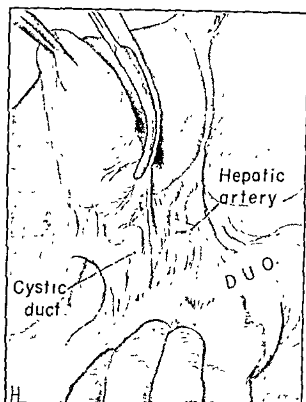



Fig. 699.—Cholecystectomy. A clamp is placed on the gall bladder just above the cystic duct, and the cystic duct and hepatic artery are exposed.

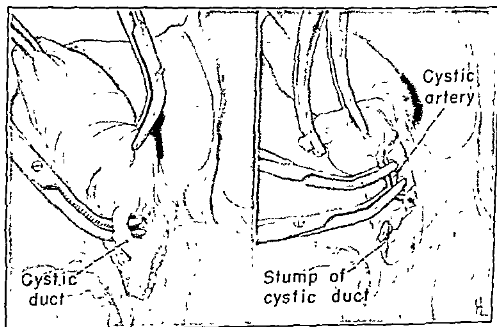



Fig 700 Fig 701

Fig. 700.—Cholecystectomy. The cystic duct has been separated from the surrounding structures and the common duct exposed

Fig. 701.—Cholecystectomy. The cystic duct has been clamped and divided and the cystic artery doubly clamped.

All sympathetic nerve fibers are cleaned away from the duct in order to prevent postoperative pain due to neuroma formation which Womack and Crider suggest may occur when these nerve fibers are included in the cystic duct tie. The duct is divided between right angle gall duct clamps (Fig. 701). Care is taken not to leave too much of a remnant of the duct because of the danger of a stone forming in it (Fig. 702, *A*), and because postcholecystectomy symptoms have been attributed to cystic duct remnants. On the other hand, do not divide the cystic duct so close to

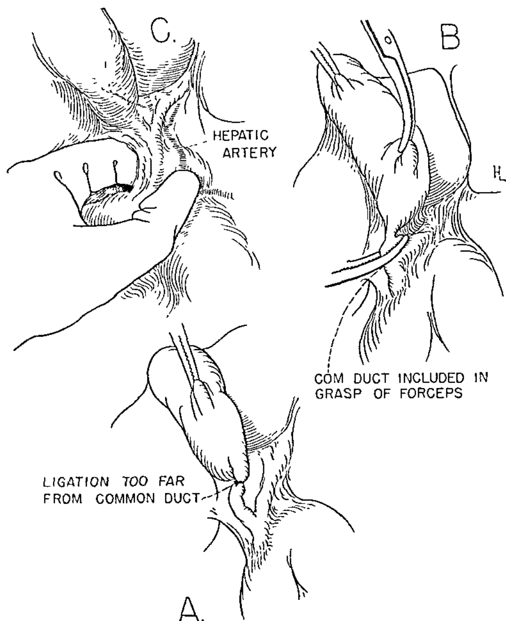



Fig. 702.—Cholecystectomy, showing (*A*) the cystic duct ligated too high, (*B*) the cystic duct pulled upward and a portion of the common duct clamped, (*C*) position of the forefinger and thumb to control bleeding from the hepatic artery.

the common duct that encroachment on its lumen will occur when the cystic duct is ligated When the common duct is mobile, it may be so tented in retracting the gall bladder upward that the common duct is included inadvertently in the clamp (Fig. 702, *B*). Occasionally the clamp or ligature slips off the cystic artery. Disaster may result in a very few minutes if the bleeding is not controlled, but the indiscriminate placing of hemostats may result in injury to the common duct. Bleeding, therefore, should be controlled by inserting the left index finger in the foramen of Winslow and

compressing the hepatic artery between it and the thumb (Fig. 702, *C*). The actual bleeding vessel can then be visualized and clamped with safety. The cystic duct and cystic artery are doubly ligated with two ligatures of chromic catgut or nonabsorbable suture material (Fig. 703). The gall bladder is removed from below upward subserosally and the liver bed is sutured over with a continuous suture of 00 plain catgut (Fig. 704). If there is bleeding from the liver bed, a Gelfoam sponge may be helpful in controlling it. A medium-sized Penrose drain is placed in the subhepatic fossa (pouch of Morison) and brought out through a stab wound. Some surgeons do not routinely employ drainage. It is a precautionary measure which does not add to the morbidity or prolong the hospital stay and which may save a life by preventing bile peritonitis. The peritoneum is closed with a continuous suture of chromic 1 catgut and the fascial layers, subcutaneous tissue, and skin with interrupted sutures of cotton or chromic catgut.



Fig. 703 Fig. 704

Fig. 703.—Cholecystectomy. The cystic duct and artery ligated and the gall bladder removed from below upward

Fig. 704.—Cholecystectomy The liver bed is sutured

*A few surgeons prefer routinely to remove* the gall bladder from above downward. Even though the below upward method is generally used, the other method may occasionally be necessary if the cystic duct and cystic artery relationship cannot be identified to permit safe clamping and division This method is most commonly employed in acute suppurative gall bladders when induration makes isolation of the cystic duct and artery very difficult. The chief objection to removing the gall bladder from above downward is that there is usually considerable oozing of blood as the branches of the cystic artery are divided

Postoperative care is most important An adequate fluid intake is maintained with parenteral fluids, if necessary, and continuous gastric suction with a Levine tube is instituted when indicated. The drain is gradually shortened and entirely removed by the fifth or sixth postoperative day

## CHOLECYSTOTOMY

This operation is rarely employed. In the past, surgeons have occasionally used it when gallstones were found in the gall bladder at the time of exploration incidental to another operative procedure, but it has been abandoned because stones and symptoms usually recur.

The gall bladder is opened, after the bile has been aspirated with the trocar or cannula, stones are removed, the mucosa is inspected, and the incision is carefully closed in layers The mucosa is closed with a continuous locked suture of chromic catgut and the serosa with interrupted mattress sutures of fine silk or cotton. The suture line is reinforced with omentum, if possible. The incision is closed in layers without drainage of the operative area. This procedure should not be employed when there is acute suppurative pathology.

If cholecystectomy cannot be done with safety, because of the primary operative procedure, it is best not to resort to a substitute measure—removal of the stones—but rather to wait and perform a cholecystectomy later as an elective procedure.

## CHOLECYSTOSTOMY

Cholecystostomy is performed rarely today, as compared with several decades ago. Modern anesthesia, antibiotic therapy, improved pre- and postoperative care have so extended the field in which cholecystectomy can safely be employed that cholecystostomy is reserved for the occasional poor-risk patient with a fulminating infection, whose condition will permit only the simplest drainage procedure.

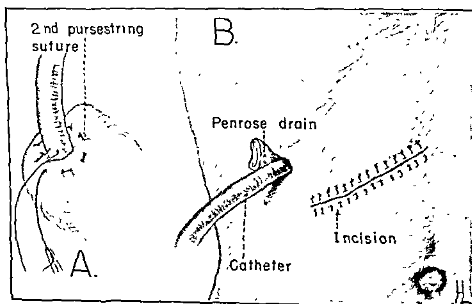



Fig 705.—Cholecystostomy. *A*, Catheter has been placed in the gall bladder and held in place with two rows of *purse-string sutures* *B*, Catheter and drain have been brought out through the stab wound and the incision has been closed.

Cholecystostomy, because of the critical condition of the patient, often is done under local infiltration and intercostal nerve block anesthesia. The abdomen is opened through a transverse or vertical incision and the operative area is carefully packed off with gauze pads. A purse-string suture of chromic catgut is first placed about the proposed opening in the fundus and the gall bladder is emptied with a trocar and cannula. The opening made by the trocar is enlarged and the edges are

grasped with Allis clamps. All stones are removed with a scoop. A large catheter or other rubber tube with several holes cut in the sides near the end is then placed in the gall bladder and the purse-string suture is tied (Fig. 705, *A*). A second purse string of the same suture material is placed and the edges are tucked in, if possible. It is wise to pass one of the sutures through the wall of the tube to prevent it from being inadvertently pulled out. The tube is brought through the omentum, if possible, and finally through a stab wound. It is not necessary to suture the gall bladder to the parietal peritoneum, but this may be done. A cigarette or Penrose drain is placed in the subhepatic fossa and brought out through the stab wound with the tube (Fig. 705, *B*). This latter drain is removed by shortening it gradually until it is entirely removed in approximately ninety-six hours. The tube is left in place two to three weeks, depending on the patient's condition. The incision is closed in layers. Cholecystectomy should be considered as an elective procedure three to four months later if the patient's condition permits, since a fair number subsequently will have trouble due to cholecystitis or to newly formed gallstones

## CHOLEDOCHOTOMY AND CHOLEDOCHOSTOMY

Choledochotomy, that is, opening of the common duct for exploration followed by closure, has been advocated by some surgeons, but it is safer to establish external drainage through a T-tube or a catheter after exploration. Routine choledochostomy is advocated by some surgeons in a majority of cases of chronic cholecystitis with cholelithiasis. The common duct should be explored if jaundice is present or if there is a history of jaundice. It should also be explored under the following conditions. palpable stone in the duct, dilated duct, thickening of duct, stones in

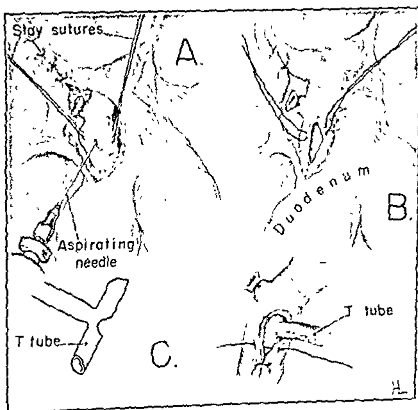



Fig. 706.—Choledochotomy *A*, The common duct has been exposed and aspirated *B*, A longitudinal incision is made in the common duct below the junction with the cystic duct *C*, The T-tube is in place and the common duct is being closed.

the gall bladder that could easily pass through the cystic into the common duct, and the presence of sediment in bile aspirated from the duct. Routine exploration may unnecessarily increase the morbidity, and even the mortality, and could possibly be a causative factor of stricture formation. These dangers probably outweigh the danger of occasionally overlooking a calculus. Good surgical judgment is most important in determining whether to explore or not to explore, rather than to employ it as a routine procedure.

The common duct, as with the gall bladder, is best exposed through a transverse (subcostal) incision. The common duct is carefully identified in its relationship to the portal vein and hepatic artery. It is a good practice to make an exploratory aspiration with a fine caliber needle to locate the duct (Fig. 706, *A*). It is opened through a longitudinal incision distal to where the cystic duct enters it after stay sutures of fine catgut have been placed on either side of the proposed opening (Fig. 706, *B*). Exploration of the common duct through the cystic duct is usually very unsatisfactory and is not advocated.

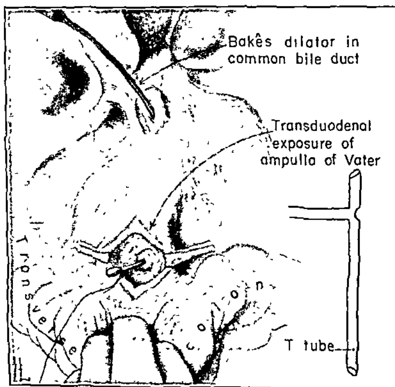



Fig 707—Exposure of ampulla of Vater as advocated by Mahorner. The common duct is opened and a dilator is passed down the common duct into the duodenum The ampulla of Vater is exposed through a longitudinal incision in the duodenum

The hepatic and the common ducts are carefully explored with scoops or stone forceps, and any calculi found are extracted. Removal of small calculi or stone debris may be facilitated by inserting a small catheter first in one direction and then in the other and flushing with warm saline solution. A malleable probe or dilator should be passed into the duodenum in order to determine whether or not a stone is lodged in the ampulla of Vater or in the sphincter of Oddi. It may be necessary to expose the ampulla transduodenally and extract the stone, as recently stressed by Mahorner (Fig. 707). The sphincter may have to be divided to accomplish this. If there is any question of being able to pass an instrument into the

duodenum, it is wise to expose the sphincter of Oddi transduodenally and directly inspect the area in order to rule out a stone, a stricture, or a tumor of the ampulla (Fig. 708).

The common duct is usually drained with a T-tube of appropriate size (Fig 706, *C*). The limbs should be 2 or 3 cm. in length. They are cut on a bevel to facilitate removal. The cross of the T is also notched opposite the insertion of the vertical limb to permit the ends to bend more easily as the tube is withdrawn. When operative work is necessary on the sphincter or ampulla, the distal limb should be long enough to pass through the sphincter into the duodenum. The opening in the duct is loosely closed about the tube with interrupted sutures of catgut. Catgut is used instead of nonabsorbable sutures to permit early removal of the tube. A Penrose drain is placed down to the foramen of Winslow and brought out with the T-tube through a stab wound. Closure of the incision is in layers, as described for cholecystectomy.

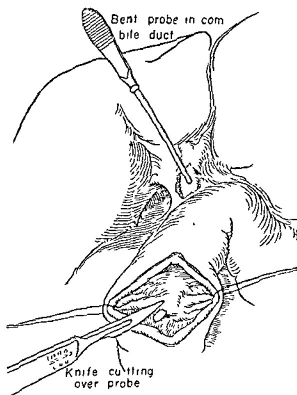



*Fig* 708—Transduodenal sphincterotomy Probe is passed down the common duct, the duodenum is opened, and the muscles of the sphincter of Oddi are divided

The T-tube should be removed in from ten to fourteen days, although in some cases it should be left for a longer period of time. Before the T-tube is removed the common duct is flushed out. A cholangiogram is indicated before the removal of the tube, if there is a possibility of stones still being present in the common duct. It may also be a valuable procedure at the operating table in visualizing calculi when one is not certain whether or not a calculus is present in the distal common duct. The duct is clamped for twenty-four hours before removal, and if no discomfort is experienced by the patient, the tube is removed. If the T-tube is not released at once by a steady pull, it is well to wait two or three days and try again. Usually it is removed with ease at this time. A defective tube might break off with too vigorous pulling. For this reason all tubes should be carefully checked before they are inserted.

A small catheter may be placed upward or downward in the duct in place of a T-tube and allowed to drain to the outside. An alternate method of draining the common duct is to place a small catheter in the duct, allowing the distal end to extend into the duodenum and the proximal end past the junction of the cystic duct, almost to the bifurcation of the hepatic duct. This catheter is held in place with catgut and the common duct is closed. A Penrose drain is carried down to the common duct and brought out through a stab wound, as described above. The catheter in the common duct always passes out into the small bowel in several weeks. Following this type of drainage of the common duct, there seem to be fewer cases of biliary fistula or common duct stricture

## CHOLECYSTENTEROSTOMY

Obstruction of the distal end of the common duct by an inoperable carcinoma of the head of the pancreas or ampulla of Vater, by an inflammatory lesion of the head of the pancreas, or by a stricture of the duct, may require the formation of a fistula between the gall bladder and the intestinal tract to by-pass the obstruction.

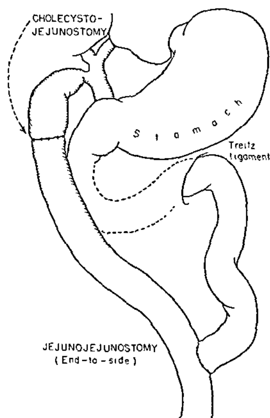



Fig. 709 —Cholecystojejunostomy. Diagram showing anastomosis of gall bladder to jejunum and site of the end-to-side jejunojejunostomy

The anastomosis can be made to the stomach, duodenum, or jejunum, but, because of the danger of ascending infection in the biliary tree—cholangitis—the anastomosis is best made to a *defunctionalized* jejunal limb formed by the Roux-Y technic (Fig. 709). The limb should be *at least 20 cm.* in length and is best brought up retrocolic. The anastomosis is made in two layers. The *mucosal* edges are approximated with a continuous locked suture of chromic catgut and the serosal edges with interrupted cotton or chromic catgut.

As an alternate procedure, a long loop of jejunum can be brought up anterior to the transverse colon and the gall bladder anastomosed to the top of the loop.

An enteroenterostomy between the limbs of the loop to by-pass the intestinal co tents is made below the level of the colon. To further block the flow of intestin contents around the loop, Cole has suggested that several infolding valves be ma in the proximal limb. These are formed by infolding the bowel wall and approx mating the serosal surfaces together transversely across the surface of the bowel several points.

In poor-risk patients all that is warranted is the simplest technical procedur which is the anastomosis of the gall bladder to either the stomach or the duodenu (Figs. 710, 711, and 712). The duodenum is preferable to the stomach, since drai age may not always be free through the anastomosis when this thick-walled muscul organ is used. Although the virulence of the bacterial flow is low in the stomac and duodenum, the incidence of cholangitis is fairly high when the anastomosis made to these organs.

Fig 710. Fig. 711.

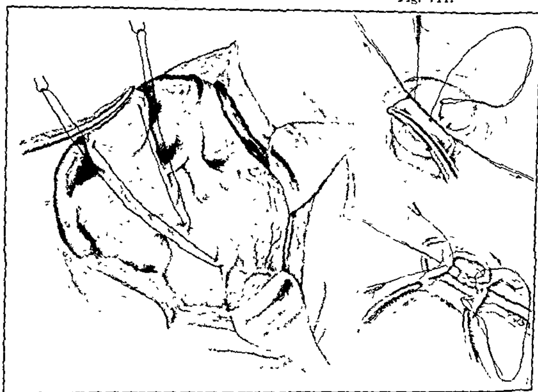


Fig 712.

Fig. 710.—The gall bladder has been emptied with trocar and cannula, and the opening temporarily closed with a clamp The tractor sutures are so placed between the duodenum and the gall bladder that the incision in the duodenum will be transverse.

Fig. 711.—The duodenum and the gall bladder may be clamped with soft-bladed clamps used for lateral blood vessel anastomosis, if it is possible to do so, and the gall bladder is sutured to the duodenum with a continuous right angle suture of 00 chromic catgut.

Fig 712.—An incision has been made in the gall bladder and in the duodenum The posterior margin of the wound in the gall bladder is sutured to the posterior margin of the incision in the duodenum with a continuous lockstitch of silk

## STRICTURE OF THE COMMON DUCT

Repair of strictures of the common duct is often very unsatisfactory. Many of the patients undergo numerous operations before they finally obtain a satisfactory result, provided they do not succumb to the operation or die as a result of the cholangitis and liver damage that so often accompany the condition Since opera-

tive trauma is the most frequent cause of stricture, the most meticulous care must be exercised in gall-bladder and biliary tract surgery to prevent this disastrous complication.

Many types of repair have been suggested (Figs. 713 through 718) and each occasionally may be found to be useful under certain circumstances. However, certain fundamentals must be followed in common duct repair. First, the distal end of the duct should be used, if possible, in order to retain the benefit of the action of the sphincter of Oddi to prevent regurgitation of intestinal contents up the biliary tree, with resulting cholangitis. The segment of common duct lying retroperitoneal to the duodenum may be 4 to 5 cm. in length. Cattell has advised splitting the head of the pancreas, if necessary, to find the distal end of the duct. Second, the preferable repair should be end of duct to end of duct with careful mucosal approximation to prevent recurrence of stricture. Third, if the distal end of the duct cannot be found, the proximal end of the duct should be anastomosed either to the duodenum or to a defunctionalized limb of jejunum formed in the Roux-Y manner. Fourth, defects should not be bridged with rubber or Vitallium tubes unless absolutely necessary, since recurrence of the stricture often results, or tubes become blocked with biliary sediment. Fifth, approximation should be made without tension. Sixth, procedures such as Longmire's intrahepatic cholangiojejunostomy with partial hepatectomy should be employed only as a last resort.

### Exploration of Stricture of Common Duct

The exploration should be done as soon as possible after the condition has been recognized. The patient is prepared with transfusions of blood and vitamin K therapy. A transverse (subcostal) or a vertical incision may be used. It has been suggested that a right thoracoabdominal incision might be used to advantage. Structures adherent to the undersurface of the liver are carefully dissected away until the proximal stump of the duct is identified in the hilar area. Aspiration with a fine hypodermic needle and syringe may be very helpful in identifying the structures. The distal end of the duct is exposed by dividing the lateral peritoneal attachment and rotating the duodenum mesially to expose its undersurface. As previously mentioned, the head of the pancreas should be split, if necessary, in order to locate the duct.

### Resection of Stricture and End-to-End Anastomosis

The two ends of the duct, in many cases, can be mobilized sufficiently to perform an end-to-end mucosal anastomosis (Fig. 713, *A*). The stricture must be resected to prevent recurrence. One layer of interrupted fine silk or cotton sutures is employed. The suture line is splinted with a T-tube or catheter which is inserted through an opening distal to the anastomosis (Fig. 713, *B*). It may not always be practical to use a T-tube. In this case, the anastomosis is made over a small piece of rubber tubing with the distal end protruding into the duodenum. A silk thread is anchored to the tube and brought out through the duct wall to the skin surface, where it is attached to a button in order to maintain it in position. When the thread is cut, the tube will pass on into the duodenum. The T-tube or tube splint should be kept in place for at least three months. A cigarette or Penrose drain is placed in the pouch of Morison and brought out through a stab wound with the T-tube.

Lahey has devised a T-tube with a split or double end, *one-half of the tube* being inserted in the right hepatic and the other half in the left. He has also devised a technic of converting the two hepatic ducts, when the site of the stricture

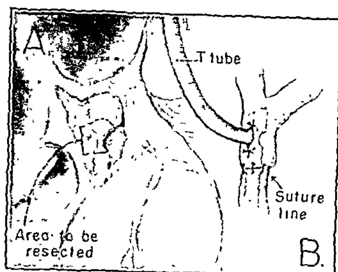



Fig 713—Repair of stricture of common bile duct. *A*, The stricture and area to be resected are shown *B*, The common duct is sutured with a T-tube in place.

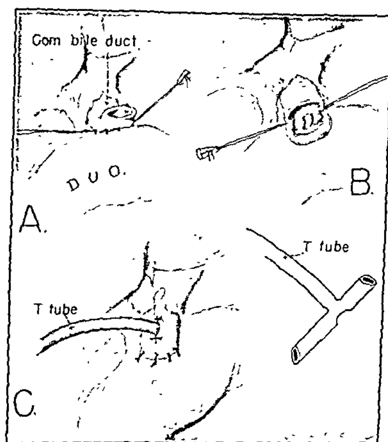



Fig 714.—Choledochoduodenostomy—end-to-side. *A*, Serosal coat of duodenum and common duct sutured. *B*, Opening made in the duodenum and the mucosa of the duodenum and common duct sutured. *C*, Anastomosis complete and T-tube in place

is at that level, into a common channel in order to facilitate end-to-end anastomosis. The two ducts are sutured together anteriorly and posteriorly with fine interrupted sutures of cotton or silk, after which the septum between the suture lines is divided.

### End-to-Side Choledochoduodenostomy

This procedure is used when the distal end of the duct cannot be found and there is a fairly long proximal segment or in cases of stricture of the sphincter of Oddi (Fig. 714). The anastomosis is made in two layers and must be mucosa to mucosa. The mucosal layers are approximated with interrupted chromic catgut and the serosa with interrupted sutures of cotton or silk. A small rubber tube drain can be placed in the duct and allowed to protrude through the anastomosis as a splint, or a T-tube with a limb extending through the anastomosis can be brought out through an opening in the duct proximal to the anastomosis. These are not absolutely necessary. A cigarette or Penrose drain is placed down to the operative area.

### Side-to-Side Choledochoduodenostomy

This procedure, as described by Sanders, may be of value, particularly in dealing with strictures of the distal end of the duct or with choledochal cyst. A longitudinal incision is made in the common duct and the duodenum, and the anastomosis is made between the two in two layers (Fig. 715). The mucosal layers are approximated with interrupted sutures of chromic catgut and the serosa with silk

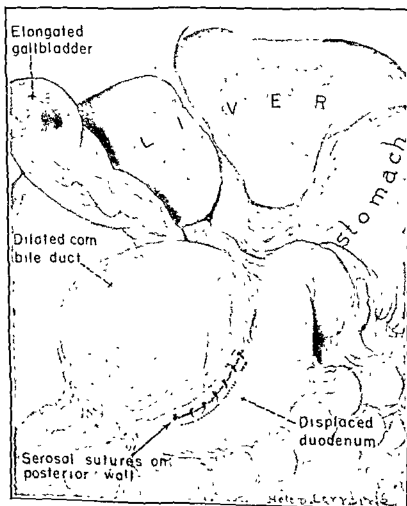



Fig. 715.—Choledochoduodenostomy—side-to-side. Dilated common bile duct is shown. The serosal edges have been sutured and the lines of incisions to be made in the duct and duodenum are shown.

or cotton. Keeley anastomosed a Roux-Y limb of jejunum to a choledochal cyst in order to prevent regurgitation of intestinal contents (Fig. 716). This is probably a better procedure than choledochoduodenostomy.

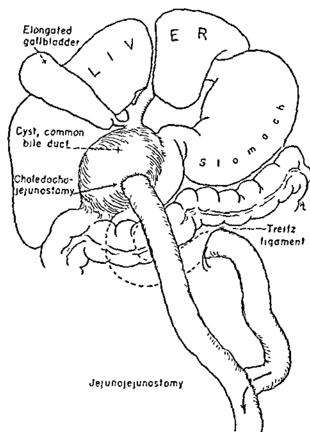



Fig. 716.—Choledochojejunostomy. Roux-Y type of anastomosis of jejunum to a dilated common bile duct.

## Roux-Y Choledochojejunostomy

This procedure is primarily used when there is only a hilar pouch of the proximal duct present or when the only duct available is located in the liver. The defunctionalized limb of jejunum may preferably be used instead of the duodenum when the proximal duct segment is fairly long, since there is less danger of ascending infection. The jejunum is divided approximately 40 cm from the ligament of Treitz and the limb made at least 20 cm. long. The limb is brought up either through an opening in the mesocolon or anterior to the colon, depending on the local relationship of organs. A number of technics for making the anastomosis have been developed.

If there is a fairly long proximal segment, the anastomosis is made end to end in two layers with mucosa-to-mucosa approximation (Fig. 717). Because of the difference in size, it may be technically easier in some cases to close the end of the jejunum and perform an end-to-side anastomosis The mucosal surfaces are approximated with interrupted sutures of fine chromic catgut and the serosal surfaces with interrupted fine silk or cotton. The anastomosis should be made over either a small rubber tube or a T-tube. The rubber tube is anchored by fixing it with a silk suture, which is brought out through the duct and attached to a button on the skin surface. The tube passes on into the intestinal tract when the thread is cut. The T-tube is brought out through the duct proximally to the anastomosis The tubes are left in situ for at least three months.

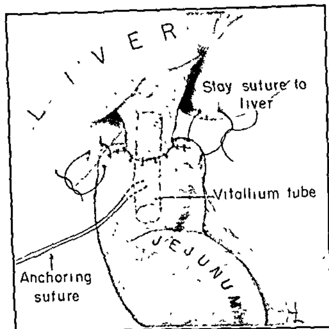



Fig. 717.—Choledochojejunostomy—end-to-end The anastomosis has been completed over a Vitallium tube. The anchoring suture for the tube is shown The stay sutures between the under surface of the liver and jejunum have been placed.

Fig 718.—Allen's method of cholangiojejunostomy. *A*, Diagram showing the cholangiojejunostomy and the jejunojejunostomy with the catheter in place. *B*, Cross section of the anastomosis showing the position of the Vitallium tube and the rubber catheter.

Allen's Method.—This method is of value in anastomosing a small proximal pouch to the jejunum (Fig. 718). A rubber tube is threaded up into the duct and a Vitallium tube is threaded over it as a support for the anastomosis. The edges of the open upper end of the jejunum are turned in to form an inverted cuff, and the edges of the cuff are held in place with a number of interrupted sutures. The proximal end of the rubber tube is inserted in the jejunal limb and brought out

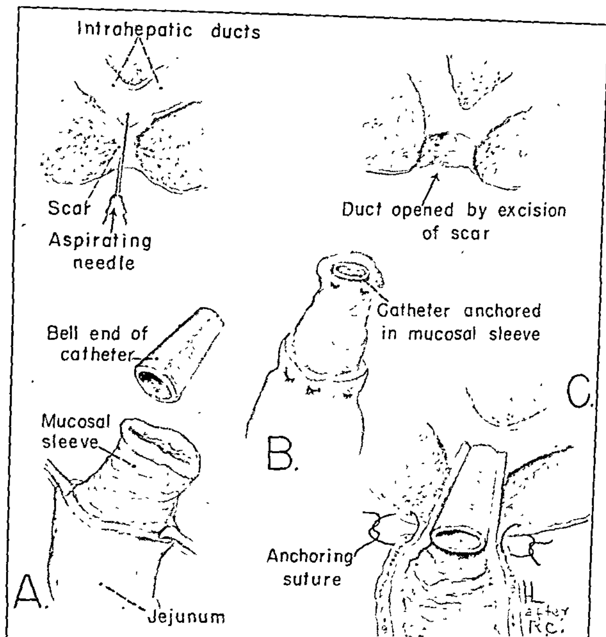



Fig 719.—Cole's method of cholangiojejunostomy. The intrahepatic ducts are located with an aspirating needle and the ducts are opened by excision of scar tissue *A*, The mucosal sleeve has been dissected free of serosa *B*, The bell end of a catheter has been placed in the mucosal sleeve *C*, Cross section of the completed anastomosis.

through a stab wound 15 to 18 cm. from the end of the limb. The upper end of the jejunal limb with the inverted cuff is then sutured to the liver about the duct, or to the duct itself, if possible, with interrupted sutures of fine silk or cotton. The jejunum is closed about the rubber tube where it exists with two purse-string sutures of chromic catgut and the tube is brought out through a stab wound. A hole is cut in the side of the tube before it exits from the jejunum to allow the bile to flow

The left lobe of the liver is removed to expose the left intrahepatic duct. Mattress sutures of No. 2 chromic catgut are placed before the lobe is amputated and are tied afterward to control bleeding (Fig. 720). The end of the duct is anastomosed to a Roux-Y limb of jejunum with mucosa-to-mucosa approximation, as advocated by Wilson (Fig. 721). The anastomosis is made in two layers, 000 chromic catgut being used for the mucosa and interrupted silk or cotton to suture the serosa of the jejunum to the cut surface of the liver.

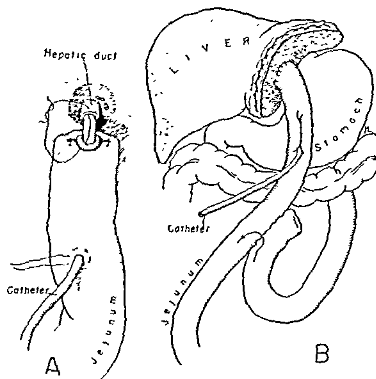



*Fig. 721.*—Wilson-Longmire intrahepatic cholangiojejunostomy. *A*, The jejunum has been brought up to the hepatic duct, the duct catheterized, and the catheter brought out the side of the jejunum. *B*, *Anastomosis complete, also showing side-to-side jejunojejunostomy.*

## PORTAL HYPERTENSION

Hypertension in the portal system may be due to extrahepatic or intrahepatic block. Extrahepatic block, which is usually due to thrombosis, involves one of the radicals of the portal system, most commonly the splenic vein or the portal vein before it enters the liver. A block rarely occurs in the hepatic vein between the liver and the inferior vena cava. Intrahepatic block is usually due to cirrhosis.

Portal hypertension may result in three complications: (1) splenomegaly with hypersplenism—secondary anemia, leukopenia, and thrombocytopenia, (2) hemorrhage from the gastrointestinal tract—usually gastric or esophageal varices; and (3) ascites. A number of operative procedures have been devised to control these complications. Acute hemorrhage from esophageal varices can be controlled by tamponade with a balloon attached to a tube passed down the esophagus. It also may be controlled temporarily by the injection of sclerosing solution through an esophagoscope into the varices. In the past the vessels about the esophagogastric junction have been ligated, but the results generally have been unsatisfactory Lord has listed a total of eleven procedures performed for portal hypertension, and recently another has been proposed by Rienhoff. The procedures either attempt to

create new pathways or shunts between the portal and systemic systems in order to by-pass the block, or to decrease the amount of blood flowing into the portal system by removing organs such as the spleen, stomach, and lower end of the esophagus. Rienhoff has suggested that, in cirrhosis, since the amount of hepatic artery blood flowing through the liver may be increased from 25 per cent of the total blood flow through the liver to as much as 80 per cent, ligation of the hepatic artery at its origin should provide a larger vascular bed for the passage of the portal blood. These surgical procedures, unfortunately, are too often employed as a last resort, after the patient's condition has become so deteriorated as to make surgery hazardous and the results unsatisfactory. In liver cirrhosis every effort, however, should first be made to improve the physiopathologic changes with the accepted medical regimen before considering surgical intervention.

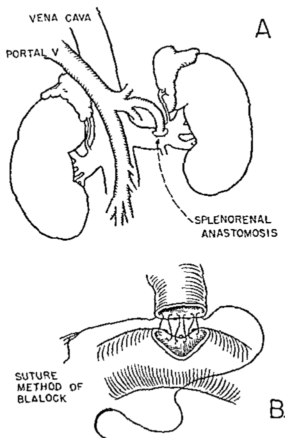



Fig 722.—Splenorenal shunt. *A*, Diagram showing the anastomosis of the splenic artery to the left renal vein. *B*, Details of the anastomosis of the artery to the vein.

## Shunt Operations

Whipple, Blakemore, and Lord are responsible for the recent interest and for many of the advances that have been made in the field of portal hypertension. They first developed a technic for anastomosing the splenic vein to the renal vein after splenectomy and nephrectomy, employing a nonsuture technic with a Vitallium tube. Linton and others later devised a suture type of end-to-side splenorenal anastomosis with splenectomy and preservation of the kidney, which is a preferable procedure to the other since the kidney is preserved and since possibly there is less chance of the anastomosis being narrowed or blocked by thrombosis (Fig. 722). Splenorenal shunt is indicated in most cases with extrahepatic block.

A portacaval shunt (Eck fistula) is indicated *when the block is* intrahepatic. Blakemore and Lord first devised a nonsuture technic using a Vitallium tube to perform an end-to-side portacaval anastomosis. A more satisfactory procedure has been a side-to-side *suture technic anastomosis.* The portacaval anastomosis is preferred to the splenorenal shunt because stenosis or thrombosis of the anastomosis *is less frequent,* although there is the advantage of reducing the portal load by 25 to 40 per cent when the spleen is removed.

If the block is in the portal vein and the spleen has previously been removed, *the superior or inferior* mesenteric vein is anastomosed to either the inferior vena cava, renal, ovarian, or spermatic vein. The results with these anastomoses have not been satisfactory.

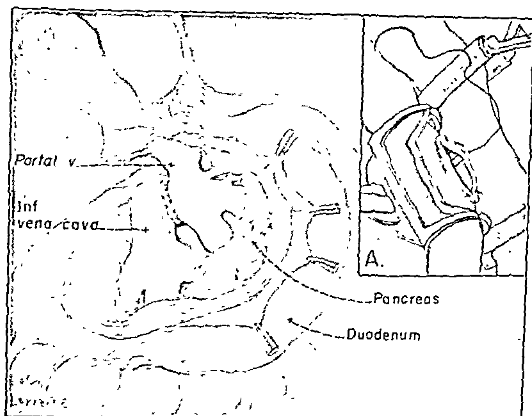



*Fig. 723.—Portacaval lateral anastomosis, showing use of a Potts clamp and anastomosis completed*

**Splenorenal Shunt.**—The ideal approach is through a left *thoracicoabdominal* incision with the left side of the patient elevated. The incision is made through the bed of the ninth rib and divides the left rectus muscle transversely. The incision is described in detail in Chapter 46. The spleen is mobilized and the pancreas is *separated from the splenic root* *The spleen is removed, care being taken* to preserve a good length of the splenic vein. Pancreatic branches are divided and ligated in order to obtain sufficient length of vein for a free anastomosis. The renal vein *is exposed and the* splenic vein is anastomosed to it end to side A continuous mattress everting suture of five 0 braided silk on a curved atraumatic needle is employed. In this way, intima-to-intima *approximation is obtained* *The suture* should be interrupted at several points to prevent narrowing of the lumen.

**Portacaval Shunt.**—The approach is best made through a right thoracicoabdominal incision as described by Satinsky *The incision is made through the* bed

of the ninth rib. The portal vein may be divided and anastomosed to the inferior vena cava end to side, but a side-to-side anastomosis which does not obstruct the flow of blood through the vena cava is preferred (Fig. 723). The peritoneum is divided and the duodenum and common duct are displaced mesially until the portal vein and inferior vena cava are exposed at the point they run side by side. The portal vein is occluded with bulldog clamps and the wall of the vena cava selected for the anastomosis is occluded from the lumen of the vessel with a Potts clamp or with a clamp especially devised by *Blakemore* without interrupting the flow of blood The Smith-Freeman clamp, which includes a portion of the wall of each vessel without obstructing the lumen of either, has been used by Julian and Metcalf. The only disadvantage noted by them was that the clamp did not provide sufficient space for the use of an everting mattress suture.

A longitudinal incision is made in each vessel of as great length as the proximity of the vessels to each other and as the Potts or Blakemore clamps will permit. A continuous mattress everting suture of five 0 braided silk is used. This is interrupted at several points. The clamps are first removed from the portal vein and then from the vena cava.

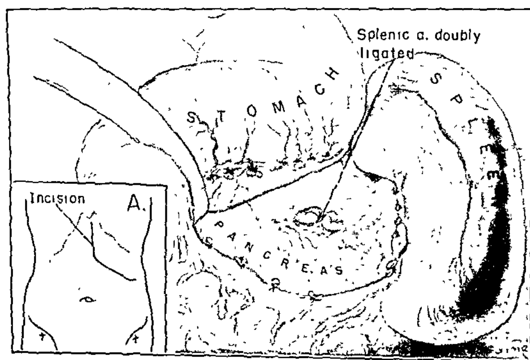



Fig 724—Ligation of the splenic artery. The gastrocolic omentum has been divided, the bleeding vessels have been ligated, and the splenic artery has been doubly ligated. *A*, Preferred type of abdominal incision for this procedure.

## Splenectomy and Splenic Artery Ligation

In those cases with thrombosis of the splenic vein, splenectomy will produce a satisfactory result. In portal vein block or intrahepatic block, splenectomy is *not* a satisfactory procedure, although temporary improvement may result, since 25 to 40 per cent of the portal load may be removed by this means. In patients who are not good risk for portacaval shunt or splenectomy, Cole, Moore, and others have suggested ligation of the splenic artery (Fig. 724).

### Omentopexy

The best known of the older operations to produce a shunt is omentopexy. This operation, which was devised independently by Rutherford Morison and by Talma, is sometimes satisfactory in ascites from cirrhosis of the liver but has been generally supplanted by the new shunt procedures.

The abdomen is opened to the right of the midline above the umbilicus and all the ascitic fluid is evacuated. With dry gauze the upper surface of the liver is rubbed to form adhesions between the liver and the diaphragm. The spleen is similarly treated. The omentum is then pulled into the wound and united to the anterior parietal peritoneum and the margins of the wound. Usually there has been much distention with the ascites, and after the fluid has been evacuated the abdominal wall can be everted to expose a considerable area of the parietal peritoneum. The omentum is sutured around the wound as far from the incision as possible, particularly far over on the left side. After both sides are sutured, the wound is closed with interrupted sutures of silkworm-gut. A stab wound is made in the lower abdomen above the pubis and a tube is inserted to drain off the fluid in the pelvis. This is necessary, for the fluid, if allowed to accumulate before the anastomosis of the small vessels has formed, will interfere with the union of the omentum to the peritoneum. This operation can often be done under a local anesthetic.

The Mayos modified this method by making one incision on the right side over the liver as near the deep epigastric and internal mammary vessels as possible and a second incision 10 cm. below this through the rectus muscle, but not through its posterior sheath. After extensively separating the muscle from its posterior sheath, a portion of the omentum is drawn through the upper part of the incision and pulled down into the pocket where it is fixed in position with a few sutures. A similar procedure can be carried out on the left side and the intervening segment of omentum may be united to the parietal peritoneum. These operations done in the early stage often afford much comfort and relief from ascites, but, of course, they are not curative of the cirrhosis, though they may make conditions more favorable for hepatic repair.

### Resection and Devascularization of the Esophagogastric Bleeding Segment

An entirely satisfactory answer to the control of hemorrhage from esophageal varices has not been supplied by portacaval anastomoses because of the inability always to construct and maintain a satisfactory stoma and also because esophageal varices exist sometimes without portal hypertension. Because of this, Phemister and Humphreys have advocated the resection of the bleeding segment (Fig 725). The lower end of the esophagus and the cardia of the stomach are usually resected, but a total gastrectomy may be indicated to eliminate the erosive action of the acid chyme. A splenectomy should be done at the same time if the spleen has not been previously removed. It is granted that resection of the bleeding segment only transfers the load to the portal system at some other point, but experience has been that hemorrhage has not occurred at these points.

Gray and Whitesell, following the work of Phemister and Humphreys, have employed devascularization of the lower part of the esophagus and the cardia of the stomach, splenectomy, bilateral vagotomy, and gastroenterostomy. They have suggested that in the absence of changes in the liver or portal system, esophageal varices

.ay be the result of back pressure in the azygos system. The azygos veins are un-ıpported and lack valves and, as a result, may develop a high back pressure of .ood. These veins should be adequately resected in devascularizing the esophagus. 'he vagus nerves are resected in order to reduce the acid chyme because of the rosive action of the regurgitated chyme on the varices, as suggested by Wangen-ɩeen. The gastroenterostomy is done to insure adequate gastric drainage following he vagotomy.

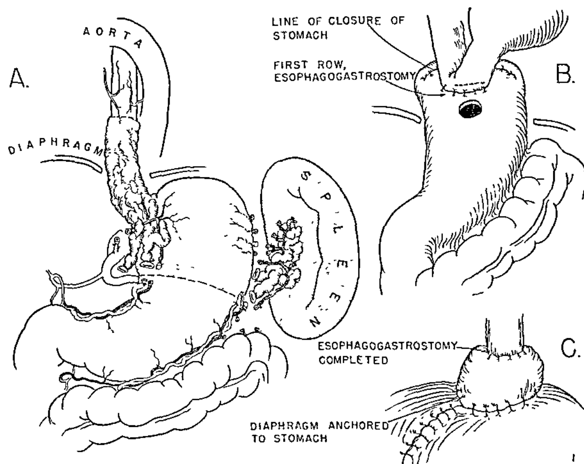



Fig 725.—Resection of lower esophagus and cardiac end of stomach for bleeding varices. *A*, Stippled area, including spleen, to be removed *B*, Cardiac end of the stomach has been closed and the anastomosis of the esophagus to the stomach is begun. *C*, The anastomosis between the stomach and esophagus has been completed.

Resection of the bleeding segment or devascularization is done under intratracheal anesthesia through either a transthoracic or thoracicoabdominal incision, although an abdominal incision may be preferred by some. Details of esophagogastric resection are described in Chapter 38. In devascularization, all surface vessels are removed from the lower segment of the esophagus down to the muscular layer. Both vagus nerves are resected and a complementary gastroenterostomy is done for drainage. A splenectomy is done in both procedures.

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# CHAPTER 63

# THE PANCREAS AND SPLEEN

BENJAMIN W. RAWLES, JR.

## THE PANCREAS

In the past, extensive operations on the pancreas were infrequent because of prohibitive high mortality. As a result of modern anesthesia, antibiotic therapy, physiologic pre- and postoperative care, including whole blood transfusions, the surgeon today is able to resect the entire pancreas and encircling duodenum, if indicated, with a relatively low mortality rate.

Adequate exposure of the pancreas is best obtained through an upper abdominal transverse incision with division of both recti muscles, although satisfactory exposure can be obtained through a vertical type of incision. The pancreas is exposed by dividing the gastrocolic omentum and retracting the stomach upward. Because of a high position of the pancreas in its relation to the stomach in some instances, it occasionally may be more directly approached through the gastrohepatic omentum.

### Trauma of Pancreas

The pancreas is vulnerable to injury by blunt trauma because of its position overlying the spine. It also may be injured by stab or gunshot wounds. The injury should be repaired, if possible, particularly if the pancreatic duct is torn or lacerated. Nonabsorbable sutures are used for the repair. Soft rubber tissue drains are placed down to the site of injury to take care of any drainage. If surgery is delayed, acute pancreatitis may develop so that surgery is of necessity restricted to simple drainage.

### Acute Pancreatitis

Conservative measures offer the best prognosis in the management of acute pancreatitis Gage and others have stressed the importance of relaxing the sphincter of Oddi by means of either a bilateral splanchnic block with procaine or an epidural continuous spinal anesthesia in order to provide for the free flow of bile and pancreatic juices, since it is generally believed that the reflux of bile into the pancreatic duct system under pressure results in autodigestion and tissue damage.

As soon as a clinical diagnosis of pancreatitis is made or even suspected, blood is taken for an amylase determination, and while waiting for this report a splanchnic block is done (Fig. 1274). If the diagnosis is correct, the patient is usually relieved immediately of the acute abdominal pain. Pain from other acute abdominal

reserved for those cases with advanced pathology such as found in calcification or cystic degeneration. Division of the sphincter or by-passing the biliary flow should not be necessary if the spasm of the sphincter is overcome by other methods.

## Pancreatic Cysts

Cysts in the pancreas may be either true or false (pseudo) cysts. The true cyst may develop spontaneously or it may develop as a complication of chronic pancreatitis. The pseudo cyst may form as a result of traumatic hemorrhage or pancreatitis. The true cyst may be a benign papillary cystadenoma or a malignant papillary cyst adenocarcinoma. Biopsy for microscopic study should be done on the wall of every pancreatic cyst. All cysts are excised, if possible. If resection is not technically feasible, the cyst is either drained internally into the stomach or small intestine—cystgastostomy or cystenterostomy—or it is drained externally—marsupialization. Partial pancreatectomy is indicated in selected cases.

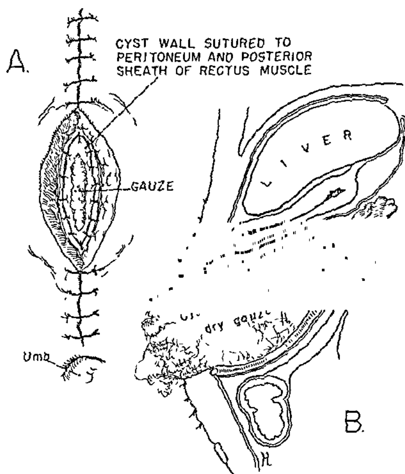



Fig 726.—Marsupialization of pancreatic cyst. *A*, The cyst wall is sutured to the peritoneum, the abdominal wound closed, and the cyst packed with gauze. *B*, Cross section of cyst showing the gauze in place.

**Excision of Pancreatic Cysts.**—Pancreatic cysts are approached through a vertical rectus muscle-splitting incision, rather than a transverse incision, because this type of incision is better adapted to the suturing of the edges of the cyst wall to the edges of the incision in the event the cyst has to be marsupialized. The cyst most commonly presents above or below the stomach, and the approach, therefore, is through the gastrocolic or gastrohepatic omentum. Resection should be carried

out, if possible. This may be facilitated by opening the cyst and inserting a finger as a guide for the dissection. After the resection, the defect in the pancreas should be closed with interrupted sutures of silk or cotton. A Penrose drain is placed down to the operative site and brought out through a stab wound. The drain is gradually shortened, but it should not be entirely removed for ten to fourteen days. In some cases of pancreatic cyst, particularly in those patients with chronic pancreatitis with calcification, or patients who have had recurrent attacks of acute pancreatitis, partial pancreatectomy with resection of the tail and body of the gland is technically more feasible than simple resection of the cyst.

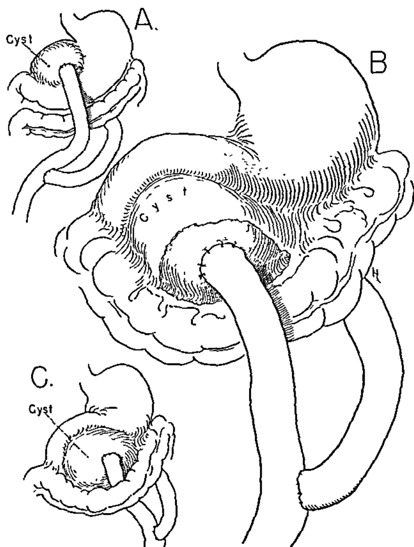



Fig. 727.—Drainage of pancreatic cyst into the jejunum, showing different sites of anastomosis, using Roux-Y type. Anastomosis of cyst to jejunum: *A*, on the lesser curvature of the stomach; *B*, along greater curvature of stomach and anterior to colon; *C*, along greater curvature of stomach and posterior to colon.

**Marsupialization of Pancreatic Cysts.**—Marsupialization can be done in one or two stages The one-stage procedure is usually employed, since the cyst is usually opened to determine whether or not it can be resected and also for the purpose of inspection and biopsy of the cyst lining (Fig. 726, *A*). The edges are sutured to the edges of the peritoneum and posterior rectus sheath with interrupted sutures of catgut. The incision is closed above and below the opening into the cyst and the cyst is packed with dry gauze (Fig 726, *B*). If the cyst is infected, it can be handled

by the two-stage method. The wall of the unopened cyst is sutured to the edges of the incision and the cyst is incised and drained five to six days later, after the peritoneal cavity has become sealed off. Pancreatic fistulas often result following marsupialization. Therefore, it should be used only when the other methods are not applicable.

Cystenterostomy.—Internal drainage was first performed by Hahn in 1927 when he anastomosed a pancreatic cyst to the jejunum. Recently Poer, Migliaccio, and others have advocated internal drainage. Since some cysts are multiloculated, care must be taken to break down the septa so that the entire cyst is drained. If the cyst presents through the gastrohepatic omentum, it may be anastomosed to the stomach with ease. The acid chyme, however, may cause erosion and hemorrhage, and for this reason this anastomosis is not advocated. The proximal loop of jejunum may be anastomosed to a cyst through an opening in the mesocolon when the cyst presents in this direction, or a long loop may be brought up anteriorly and anastomosed to a cyst presenting above the stomach. A complementary entero-enterostomy is done below the level of the transverse colon in order to by-pass the intestinal contents when a long loop is used. Since intestinal contents may cause infection in the cyst, the drainage of the cyst into a defunctionalized Roux-Y loop of jejuum at least 20 cm. in length is the procedure of choice (Fig. 727). The anastomosis, in all instances, is made in two layers, the internal being a continuous suture, and the external, interrupted Lembert sutures, using chromic catgut, silk or cotton

## Pancreatic Fistulas

Pancreatic fistulas may develop following traumatic rupture of the organ, resection of the head, partial resection of the body, or marsupialization or excision of a cyst. These fistulas usually close spontaneously in six to eight weeks. Drainage may be so profuse at first that it is difficult to maintain the patient in metabolic balance. Excellent results have also been obtained by employing total intravenous alimentation. The secretion is very irritating to the skin about the fistula and aluminum powder or paste should be applied to the skin to protect it The irritation of the skin can be prevented sometimes by inserting a Foley catheter in the tract and applying suction with a Stedman pump. Secretion around the catheter is prevented by inflating the bag of the catheter. Sclerosing solution may be helpful in obliterating the tract. The solution may be instilled in the tract, or the tract, if it is large enough, may be packed with a narrow gauze strip soaked in the sclerosing solution.

If the fistula persists, it is carefully dissected free and implanted in the intestinal tract. The stomach usually is more easily accessible, but a loop of jejunum may be used. The anastomosis is made in two layers with interrupted sutures of fine silk or cotton If the fistula is the result of drainage of a pancreatic cyst associated with chronic pancreatitis, the advisability of partial pancreatectomy should be considered.

## Sympathectomy for Pain From Chronic Pancreatitis

Epigastric pain may be so severe that some patients develop an addiction to narcotics De Takats and Walter, Ray and Console, and others have advocated sympathectomy to relieve pain. All agree that approximately 8 cm. of the greater

splanchnic nerve should be resected and also the sympathetic trunk from either the eleventh thoracic to the first dorsal or from the ninth to the twelfth thoracic, one side being done at a time. The first side to be done is selected on the basis of the pattern of pain. If the pain is not completely relieved by resection of one side, then the other side is done. A dorsal sympathetic block (sixth to twelfth dorsal) with Novocain may be of help as a therapeutic test and as an aid in selecting the side to be done first. Partial pancreatectomy should be considered in selected patients.

## Excision of Pancreatic Calculi

The pancreas is exposed by division of the gastrocolic omentum and retraction of the stomach upward. The ampulla of Vater is exposed through a longitudinal incision in the anterior surface of the second portion of duodenum. The pancreatic

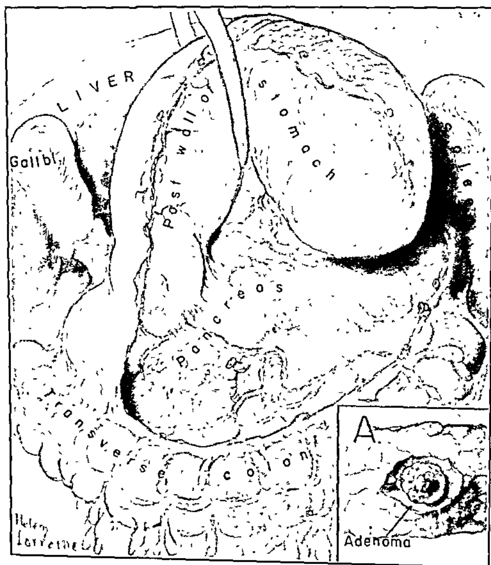



Fig. 728 —Approach to the pancreas. The gastrocolic omentum has been divided and the stomach lifted upward. *A*, Enucleation of adenoma of pancreas.

duct is probed until a calculus is encountered. An incision is then made down through the parenchyma overlying the probe until the duct is exposed. The calculi are removed with forceps and the duct is flushed out with saline. The defect in the pancreas is carefully repaired with interrupted fine silk or cotton sutures and

the opening in the duodenum is closed transversely with chromic 00 catgut for the mucosa and interrupted cotton or silk for the serosa. A Penrose drain is placed down to the pancreas and brought out through a stab wound.

## Excision of Adenoma of Islet Cells

Islet cell adenomas may easily shell out or they may have to be removed by resection of a wedge of pancreas. The entire gland must be carefully palpated when searching for these tumors, since more than one may be present (Fig. 728, *A*). Exposure of the gland must be adequate. The duodenum should be mobilized so that the head can be properly palpated. The defect in the gland is closed with interrupted sutures of cotton or silk. It is usually wise to place a drain down to the operative site In some cases of hypoglycemia the surgeon may not be able to palpate the tumor and he may assume that hypertrophy of the gland is responsible for the hyperinsulinism and the resulting hypoglycemia. This is rarely, if ever, the case. Resection of the tail and body, under these circumstances, probably has only a 50 per cent chance of removing the nonidentified adenoma.

## Partial Pancreatectomy

Partial pancreatectomy may be indicated in a number of conditions. It may be technically more feasible to manage some small pancreatic cyst by partial pancreatectomy rather than by simple excision of the cyst. Partial pancreatectomy may also be done for carcinoma confined to the tail or distal body and for chronic pancreatitis

The approach for partial pancreatectomy is through an upper transverse abdominal incision and through the gastrocolic omentum (Fig. 728). If the body is to be removed, the gland distal to this point should also be included, since a pancreatic fistula probably would develop from the distal segment. Removal is facilitated by excision of the spleen, since the splenic vessels are so intimately related to the pancreas. They usually run along the superior border but may run posteriorly. The peritoneum over the gland, if it is free, is first divided and the spleen is then freed from its attachment to the diaphragm, stomach, and colon. The spleen is lifted forward, bringing the tail of the pancreas up with it. The pancreas is freed posteriorly until the desired level of division is reached If the peritoneum is not free over the pancreas, it is divided superiorly and inferiorly as the dissection progresses. The splenic artery and vein are doubly ligated with ligatures of silk or cotton and the gland is transected at the selected point. The proximal end of the transected gland is closed with interrupted mattress sutures of cotton or silk. The pancreatic bed is drained with a Penrose drain, which is brought out through a stab wound. No attempt is made to close the peritoneum posteriorly. The gastrocolic omentum is closed with interrupted sutures of fine nonabsorbable material or catgut.

## Pancreatoduodenectomy

Malignant tumors of the head of the pancreas and ampulla of Vater are managed by resection of the head of the pancreas and the encircling duodenum. It is necessary to remove the duodenum in order to remove all the local lymph nodes and also because the blood supply to the two organs is intimately connected The operative mortality has now been reduced to a point that the risk of the operation is warranted, even though the chance for a cure in the case of carcinoma of the head is

very slight. Carcinoma of the ampulla has a better prognosis, and since it is usually impossible to tell at the operating table the exact origin of the lesion, every patient with a resectable lesion in the region of the head deserves this one chance for a cure. Whipple, Parsons, Cattell, Brunschwig, Trimble, Orr, Waugh, and many others contributed to the perfection of the technic of pancreatoduodenectomy.

The approach is through an upper transverse abdominal incision and through the gastrocolic omentum. Exploration is carried out first to determine whether or not one is dealing with a tumor and, second, to determine, if one is found, whether or not it is operable. Biopsy of the lesion is practically a futile procedure because a negative report for tumor does not rule one out, since the lesion may be located deep in the center of the mass Cattell has suggested the principle that radical surgery is indicated in the presence of a palpable tumor in the head of the pancreas, if there is dilatation of either or both biliary and pancreatic duct systems. Dilatation of the pancreatic duct is noted by gently running the finger across the pancreas transversely. If the duct is dilated, the palpating finger will note a soft trench running longitudinally in the organ. The gall bladder is usually distended when obstruction of the common duct is due to tumor. Chronic pancreatitis may occasionally produce a tumefaction in the head that obstructs the duct systems, and this possibility must be borne in mind In the presence of jaundice, but in the absence of a palpable tumor, the possibility of a small benign tumor in the ampulla must be considered. The papilla is exposed transduodenally, and, if a growth is found, it is locally excised. A frozen section is done at once, and if the tumor is found to be malignant, a pancreatoduodenectomy is carried out The lateral peritoneal attachment of the duodenum is divided and the duodenum is rotated mesially to expose the portal vein and the superior mesenteric vein in order to determine whether or not the tumor has invaded them and become inoperable.

Nonabsorbable suture technic is used for the resection. The stomach is divided transversely in the distal third. The gastroduodenal artery is isolated, divided, and doubly ligated with fine cotton or silk. The common duct is next isolated and divided as close to the duodenum as the tumor will permit. The point of transection of the pancreas is next chosen. This point should be at least 2.5 cm. distal to any palpable tumor. The point of division is usually at the neck or at a point overlying the superior mesenteric vessels. A total pancreatectomy is done if the carcinoma diffusely involves the organ or if there is any question as to the extent of the tumor. Total pancreatectomy is facilitated by removing the spleen also. The uncinate process of the pancreas is carefully freed from the superior mesenteric vessels. The blood supply is finally severed by dividing and ligating the inferior pancreatoduodenal vessels. The duodenojejunal junction is freed by dividing the ligament of Treitz and the bowel is divided distal to the duodenojejunal junction. The specimen is then removed en bloc (Fig. 729).

The reestablishment of the various pathways may be done in a number of different ways (Figs. 729 and 730). The pancreatic duct is implanted in the bowel, even though some believe that it constricts and becomes obstructed in a very short time (Fig 731). The danger of pancreatic fistula is certainly less when the duct is implanted in the bowel. If the end of the pancreas is not implanted in the bowel, the pancreatic duct is ligated with silk and the parenchyma is closed with interrupted mattress sutures of silk. The end of the common duct, rather than the gall bladder, is anastomosed to the intestinal tract because there is danger of the common

duct blowing out if it is simply ligated. The type of *anastomosis, to some extent,* depends on the relationship of the various organs to each other and also on whether or not the entire duodenum is removed. *The common duct* should be anastomosed at a higher point than the gastrojejunostomy or a by-pass should be provided through an *enteroenterostomy so that the* intestinal contents do not reflux up the biliary system and cause cholangitis. It would also seem preferable, if possible, to allow the biliary and pancreatic secretions to bathe the gastrojejunal anastomosis, because of the neutralizing effect of the pancreatic juices

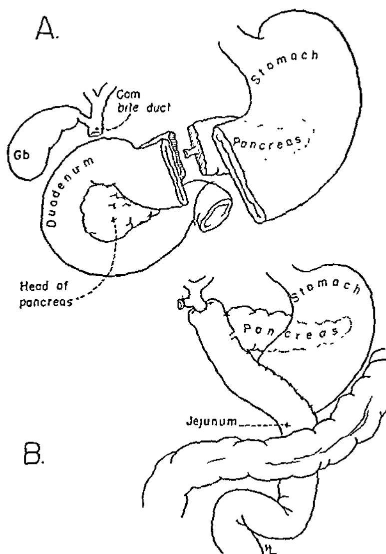



Fig 729.—Resection of head of pancreas. *A*, Diagram showing the structures to be removed by block dissection. *B*, One method of reestablishing continuity of the pancreatic, biliary, and alimentary tracts If possible, there should be more distance between the anastomosis *of the gall bladder to the jejunal loop and the anastomosis to the stomach than is indicated* in the drawing.

The following anastomosis is preferred: The jejunum is brought up through an opening in the mesocolon and used as the anastomotic limb if the bowel has been divided distally to the gastrojejunal junction. The common duct is anastomosed to the top of the limb end to end. The mucosal layers and serosal layers are approximated with interrupted 000 silk sutures and a soft rubber tube is placed in the anastomosis as a splint The cut end of the pancreas is anastomosed to the side of the jejunum just below the choledochojejunostomy, *although the relationship of the*

common duct and pancreas may make it necessary to reverse the arrangement. An opening is made in the serosa of sufficient size to permit the edges to be sutured to the edges of the normal pancreas with interrupted sutures of 000 silk. The opening in the mucosa is just large enough to permit the anastomosis of the end of the common duct to its edges—mucosa to mucosa—with interrupted sutures of fine silk. A

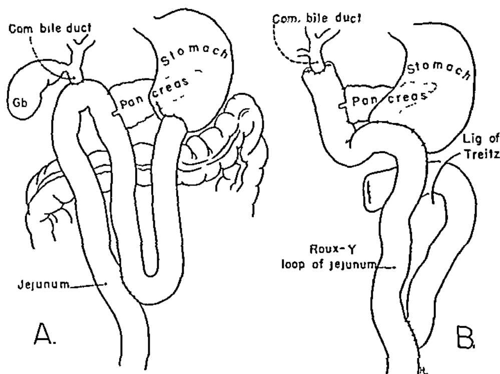



Fig. 730—Resection of head of pancreas. Different methods of reestablishing continuity of pancreatic, biliary, and alimentary tracts.

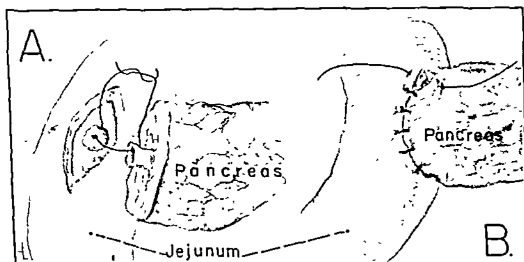



Fig 731.—Implantation of pancreatic duct into the jejunum. *A*, Anastomosis of duct to the mucosa of the jejunum. *B*, The completed anastomosis with the pancreas sutured to the serosa of the jejunum.

soft rubber tube is placed as an internal splint. A gastroenterostomy is finally performed end-to-side as far below the common duct as possible. The mucosal edges are approximated with chromic catgut, continuous locked, posteriorly, and with a Connell inverting suture anteriorly. The serosal edges are approximated with in-

terrupted Lembert's sutures of 000 silk or catgut. The edges of the opening in the mesocolon are finally sutured to the bowel.

As an alternate anastomosis the end of the jejunum is brought up anterior to the colon and anastomosed to the stomach end to end. The anastomosis is in layers, as previously described. The common duct and pancreatic duct are anastomosed to the top of a loop of jejunum brought up in the anticolic position. An enteroenterostomy is done between the efferent and afferent loops below the transverse colon in order to by-pass the intestinal contents away from the choledochojejunostomy.

If the duodenum is divided and the end closed, a Roux-Y limb can be prepared and brought up anticolic or retrocolic, and the anastomosis made to the limb—the common duct, pancreas, and stomach being anastomosed in descending order; or a long loop of jejunum can be brought up anticolic and all the anastomosis made anticolic with a complementary enteroenterostomy to by-pass the gastric contents away from the common duct and pancreatic anastomosis. Finally, several Penrose drains are placed down to the duodenal bed and brought out through a stab wound.

## THE SPLEEN

Moore has called attention to the recent change of attitude in regard to splenectomy in the treatment of blood dyscrasias. The increased knowledge of the functions of the spleen and a more careful study of the pathologic processes in its disease have defined more sharply the indications for splenectomy in certain dyscrasias of the blood. Formerly, splenectomy was done for various diseases, such as pernicious anemia and leukemia, in which the results were practically always disastrous. This reduced the enthusiasm for splenectomy. But now that the blood dyscrasias are better understood, splenectomy has come to be a more reliable therapeutic measure when properly indicated. The diagnosis of these dyscrasias is made through careful study by the internist and hematologist, as well as by the surgeon.

Splenectomy is almost specific in the treatment of congenital hemolytic icterus which is characterized by intermittent jaundice, enlarged spleen, and periods of weakness and fatigue which are associated with increased susceptibility to infections Frequently there is a history of familial illnesses that can be readily traced. A variable degree of anemia is present, along with a reticulosis, elevated icterus index, and increased fragility of the red cells with hyperplastic bone marrow. Many of the erythrocytes are spherical instead of being biconcave discs, and the clinical symptoms appear to be due to the rapid destruction of the red cells by the overactive spleen. When this enlarged spleen is removed, the symptoms disappear. Yet, even though the symptoms disappear, the spherical red blood cells may still be found. It would seem that the spleen is particularly voracious for this spherical cell Splenectomy should be done only in those patients in whom the disease is sufficiently active to produce marked clinical symptoms, as have already been outlined

Moore calls attention to one feature of congenital hemolytic icterus which he thinks has not been sufficiently emphasized. At times in patients who have this disease there are episodes of acute hemoclastic crises, in which there is a rapid fall of erythrocytes within twenty-four to forty-eight hours to 1,000,000 cells per cubic millimeter or less. These crises may be precipitated by infections, operations, accident, and emotional crises in patients who hitherto have not shown any symptoms

of the disease. Strange to say, transfusions are not beneficial in these crises, and seem to stimulate the overactive spleen to increase its phagocytic function. In such instances, splenectomy checks the hemolytic process immediately. According to Moore, Doan and his co-workers have shown that it is possible to operate upon patients in these crises even though the red cells are less than 1,000,000, and though transfusions must be avoided.

The spleen has a large storage function. Twenty or thirty minutes before the pedicle of the spleen is ligated, an intramuscular injection of about 10 minims of Adrenalin should be given. This causes the spleen to contract and pour large quantities of red cells into the circulation. The rise in red cell count produced by this autotransfusion is sometimes as great as 1,000,000 or 1,500,000 cells per cubic millimeter, and this increase is a result of a greater volume of circulating red cells, and not because of plasma concentration.

There may be relapses after the spleen has been removed, due partly to accessory splenic tissue and partly to an increase in function of the reticuloendothelial system elsewhere When accessory splenic tissue is suspected, an abdominal operation to remove it would be justified.

In selected cases of thrombocytopenic purpura a splenectomy is also indicated Moore states that it is quite necessary to guard against including in these indications the cases of thrombocytopenic purpura related to drug idiosyncrasies, food allergies, atypical leukemias, and hypoplastic anemia. If, however, the cases are properly selected and have been given a fair chance for spontaneous remission, there will be many instances in which splenectomy will offer the only satisfactory cure. Transfusion in this type, however, in contrast to congenital hemolytic icterus, is distinctly helpful and is indicated. In most of these cases in which operation should be performed, the bone marrow is well supplied with megakaryocytes. Almost immediately after a splenectomy the blood platelets increase in number and may rise much higher than the normal level. This suggests, according to Moore, that the increased phagocytic activity of the spleen for platelets is specific, and the higher platelet count which remains for several days after splenectomy is the continuing response of the bone marrow activity which had been trying to compensate for the destruction of the platelets in the spleen.

It appears, too, that some cases of leukopenia are caused by specific destruction of the granulocytes by the spleen. This type of granulocytopenia is unusual, and does not respond to the ordinary remedies, such as transfusion, liver extracts, or concentrates of bone marrow. Splenectomy is indicated in these cases. This type is quite different from Banti's syndrome and does not have a so-called splenic anemia. Banti's disease, however, is being somewhat discredited as a clinical entity, and the more it is studied the more it appears to be closely associated with hepatitis or with other diseases.

According to Moore, during the past several years it has been found that some cases of hypoplastic anemia are benefited by splenectomy. It would seem that the mechanism involved in such a disease is complicated by the fact that some cases of hypoplastic anemia have hypoplastic bone marrow, while others have hyperplastic marrow. The spleen may exert a hormonal depressant activity on marrow function, and in such instances splenectomy removes an organ which not only destroys blood cells but may also depress blood cell formation. Cases that have done better in these conditions are patients with normal or hyperplastic bone marrow.

Felty's syndrome, which is characterized by splenomegaly, leukopenia, anemia, and arthritis, may be temporarily improved by splenectomy. Other conditions mentioned by Cole which may improve to varying degrees are primary splenic neutropenia, splenic panhematocytopenia, and splenic Gaucher's disease.

Splenectomy may be necessary for traumatic rupture or laceration of the organ or for spontaneous hemorrhage and rupture complicating malaria. The history of the injury, signs localized to the right upper quadrant, and evidence of shock suggest the diagnosis of bleeding from a lacerated spleen. Transfusion of whole blood should be started at once. If loss of blood has been massive, surgery should be carried out as soon as the blood pressure has been raised above the critical level, but adequate blood must be available for use during the operation and the immediate postoperative period.

Splenectomy may be indicated in portal hypertension. This is discussed elsewhere.

Surgery of the spleen consists chiefly of splenectomy. Occasionally a wandering spleen is fixed in position, which may be best done by the method of Bardenheuer, making a pocket in the parietal peritoneum and inserting the lower portion of the spleen into this pocket. The spleen is further fixed by passing one stout suture through the lower end of the spleen and tying it around the tenth rib. As a rule, when the spleen is sufficiently movable to cause trouble, an excision is the most satisfactory procedure.

## Technic for Splenectomy

The technic of removal of the spleen depends largely upon its size. As has been mentioned, 10 minims of Adrenalin solution should be injected intramuscularly at the beginning of the operation. This empties the spleen of much of its blood. Ample exposure is always necessary. Ordinarily a left subcostal incision is preferred. Cole advised beginning this incision slightly to the left of the midline just below the ensiform and carrying it down paramedially for 5 or 6 cm. before carrying it transversely. Carter has advocated a thoracicoabdominal incision as the best incision when the spleen is of unusual size. Although some surgeons use a vertical type of incision, adequate exposure is not provided, although a T-extension to the left can be made, if necessary. If the spleen is not greatly enlarged and is nonadherent, it is turned into the wound and the pedicle is secured from behind. If the spleen is large and adherent, the operation may be exceedingly difficult. Balfour emphasized the following points in splenectomy: (1) the abdominal exploration; (2) the dislocation of the spleen; (3) the use of hot gauze packs; (4) the protection of the stomach and pancreas from injury; (5) the preliminary ligation of adhesions; and (6) the treatment of the pedicle of the spleen. The first step of the operation after exploration consists in mobilizing the spleen by thoroughly separating the adhesions between the surface of the spleen and the parietal peritoneum. If the adhesions cannot be stripped satisfactorily, they should be doubly clamped and divided. If there are many adhesions between the spleen and the diaphragm, these may be separated by the finger, or if they are large and vascular, they should be doubly clamped and divided The spleen is dislocated inward, and a large pack of gauze wrung out of hot salt solution is quickly inserted into the cavity formerly occupied by the spleen. This step is very important and not only serves to control bleeding but acts as a support from which point the spleen may be more readily handled.

The pack is not disturbed until after the completion of the operation. The main pedicle of the spleen is then brought into view from its posterior surface. It must be borne in mind that the splenic veins are exceedingly friable and may be readily injured. The dissection of the pedicle is made as close to the spleen as possible, so that bleeding from an injured vein can be more readily located. The vasa brevia are the chief vessels here. The spleen is often closely attached to the stomach, and there is the danger of injuring the stomach if clamps are placed promiscuously in this region. By doubly ligating this portion of the pedicle and then dividing between ligatures this accident may be avoided. The exact relation of the stomach is ascertained before placing the ligatures. Careful dissection of any retaining peritoneal

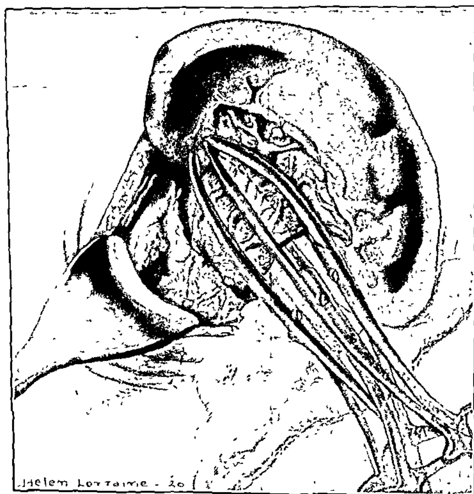


Fig. 732.—Another method of treating the pedicle of the spleen when it is difficult to expose the splenic artery (Balfour).

bands or fibers is made to mobilize the spleen, always bearing in mind the very friable nature of the splenic veins. The tail of the pancreas must be recognized. Its position is often very irregular. It may actually be adherent to the hilus of the spleen, or it may be at such a distance that it is safely out of range of injury. Sometimes the tail of the pancreas lies behind the renal surface of the spleen and sometimes it fits so closely into the hilus of the spleen as to have acquired a concave edge; or it may be in front of the splenic vessels in contact with the stomach. After the tail of the pancreas is located, it is dissected from the spleen and the pedicle with great care. The treatment of the main pedicle that is left after separating the up-

per portion of the spleen from the stomach depends largely upon the location and the arrangement of the vessels. If the splenic artery can be readily demonstrated, it is ligated before the veins are tied (Fig. 724). The splenic artery may be ligated in the lesser sac as it courses along the superior border of the pancreas. This may be helpful in diminished bleeding when dealing with a large adherent spleen. If, however, this is impracticable, the pedicle is clamped by three forceps at distances of about 1.25 cm. apart and is severed between the two forceps nearest the spleen (Fig. 732). A ligature of catgut is applied to the pedicle after removing the forceps farthest from the spleen. This ligature is placed in the crushed line left after removing the clamp. A second ligature of similar material transfixes the pedicle just below the distal clamp and is tightened as this clamp is removed. The gauze packing is then carefully withdrawn and any bleeding spots that are left are grasped with forceps and whipped over with catgut in a small round needle.

When the bleeding surface is extensive, venous in character, and difficult to control except by packing, the abdomen may be closed with the packing in position. The sutures in the abdominal wall are through-and-through sutures and are tied in a bowknot. Two or three days later the sutures are untied, the packing is carefully removed, and the abdominal wall is closed permanently with the sutures that were originally tied in a bowknot. This method seems to lessen the danger of infection which is considerable when a large amount of gauze is left in position with the ends of the gauze protruding through the wound.

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# CHAPTER 64

# OPERATIONS FOR FRACTURES

M. Josiah Hoover, Jr.

Our industrial and motor-driven age has placed in the hands of the physician a vast variety of fractures. Every resource of one's ingenuity is drawn upon in their management. There have been many tremendous advances in medical progress that have led to improvement in handling these multitudinous fracture problems. The earlier recognition and the more adequate treatment of impending or existing traumatic shock have been a great factor in the more satisfactory results. Available whole blood as a result of the introduction of storing in banks has been one of the great aids in making possible the treatment of cases that otherwise would not survive long enough for definitive treatment. Gentleness in moving these fracture patients when examinations and x-rays are being made is of such importance as never to be violated. The improved care of the shock patient has thus made possible safer and more adequate anesthesia, as have the advancements in the anesthetic agents and their administration.

Along this line of thought one naturally turns immediately to the introduction of the antibiotics and their use in the treatment of fractures as our greatest boon, for many operative procedures can be carried out with a far wider margin of safety now than ever before because of the widespread use of these amazing drugs. However, these drugs should not replace the meticulous aseptic approach in surgical care of fractures. The better understanding of the limitations and of the effects of various antiseptics on living tissues has led to greater care in preventing further insult to the injured structures. The advances in metallurgy, placing in the surgeon's hands the adequate tool for internal fixation, have proved often a solution of the unsolved fracture.

Although these ever-increasing advances and additions to the armamentarium of the fracture surgeon have made possible the solution of fractures, previously unsolved, by open reduction and internal fixation, still the majority of fresh fractures not compounded may best be treated by conservative measures. One must rely principally upon the biologic processes of reparation if the greatest degree of satisfactory results is to be obtained.

The dictum that no fracture should be operated upon that can be satisfactorily managed otherwise will rarely be violated if the fracture surgeon is aware of several principles. In the following sentences, Watson-Jones has expressed the conviction that every physician who treats fractures should bear in mind:

"The principles of the treatment of fractures must conform to biological laws and a knowledge of these principles is of greater fundamental importance than any acquaintance with the mechanical details of splints. The training of the fracture

# CHAPTER 64

# OPERATIONS FOR FRACTURES

M. Josiah Hoover, Jr.

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surgeon must begin with the physiological and pathological reactions of living tissues. Only after that does the art of surgery develop with the aid of mechanical apparatus and manipulative technic."

One of the first principles to bear in mind is that open operative reduction of a fracture disturbs the physiologic factors involved in its healing. This occurs in face of due consideration to gentleness in handling tissue. The blood supply to the fracture site is by way of the soft tissues and the periosteum. When these structures are incised, the blood supply is lessened. The healing process is interfered with when an operation is necessary. Repair begins at the time the blood at the fracture site begins to clot This primary phase of healing is lost and the process must be started over again after the surgical procedure. This delay in healing is to be expected when open operation on a fracture is carried out.

This fact leads one to emphasize the importance of early reduction of simple fractures. The sooner the fracture is reduced, the more available are the biologic processes of primary reparation. The edema about the fracture is lessened and further trauma to the soft tissues at the fracture site is prevented by fitting the bony fragments together. Under local anesthesia, using 2 per cent procaine infiltration into the hematoma, a great many simple fractures can easily be reduced. Some fractures may be reduced immediately that might require open operation if there is delay.

An important point to be remembered is the fact that the introduction of any foreign material into the normal anatomic structures causes a foreign-body reaction. The body tries to extrude the foreign material; when this is not possible, the healing process is delayed by its presence. Though delayed, the union is often seen to take place only on the side opposite the metallic fixative. This objection to internal fixation has become of less importance since the introduction of the newer inert metals. The improved methods of fixation have also made this point of less importance.

The objection to open reduction, that a simple fracture is changed into a compound fracture, assumes a minor role, for the danger of infection is reduced to a minimum in the favorable environment. The antibiotics are a valuable adjunct in the cases that warrant open operation.

When one undertakes the treatment of a fracture, Wolff's law should be remembered, for this law is an expression of the efforts of nature to restore normalcy of function. Definite changes in the external conformation and internal structure according to mechanical laws follow change in the form, position, or function of bone. This principle is a tremendous help in cases where one is concerned by a variation from the normal anatomy. Good function may be compatible with such a variation. The x-ray examination may show a rather poor reduction, but the changes that take place according to this law usually lead to a symmetrical long bone. This principle is especially applicable to the treatment of fractures in children. One should make every possible effort to obtain the nearest anatomical reduction, for the nearer perfect the reduction, the more rapid is the healing and the more normal is the function.

Certain fractures require and warrant open operation. The methods of manipulation and improved methods of traction with the aid of Wolff's law will not suffice in their treatment Each individual case must be considered. The advantages must outweigh the disadvantages.

The operation should be the simplest effective one. The technic should be that of rigid asepsis. The condition of the skin is of greatest importance, for infection must not be carried from the skin into the wound, and meticulous care of the skin is of first importance. The tissues should be handled gently, and there should be complete hemostasis. The incision should be sufficient to provide adequate exposure with the least possible retraction. Bony prominences should be avoided, if possible, when making the incision. The dissection should be sharp and should be according to the fascial planes of cleavage, avoiding muscle splitting because of the increased scar tissue that is thereby produced. The so-called Lane "no touch" technic does not appear necessary when the entire operative team is scrupulous in the detail of scrubbing. The finger can best be used because of its sensitiveness when handling the bony structures.

The ideal treatment in open operations is to place and maintain the fragments in anatomic position. After the fracture has been reduced and anatomic position obtained, it is of primary importance to maintain the result. In many cases the fragments may be locked sufficiently to maintain the reduction with only the aid of external splints of plaster of Paris. If reduction is not maintained, then metal plates, screws, or wires, must be used. When using internal fixation, the plate, screws, or wire must be entirely adequate in size and strength. Transfixing screws may be used in long oblique or long torsional fractures. The use of the Eggers slotted plate, which allows for telescoping of the fragments, has its obvious advantages. The six-screw bone plate is preferable The length of the bone plate should be approximately five times the diameter of the bone The screws are placed at a slight angle and should fix the plate to the bone, protruding through the distal cortex the length of its tap. Venable and Stuck found that Vitallium is the most inert alloy of requisite strength and the reaction of bone to it is almost nil. Because this is a cast metal, cross strain may cause the screws and plates to break. Screws and plates of stainless steel 18-8-S-MO are entirely satisfactory, are nonirritating, and are less apt to break, although the plate may have to be removed after union of the fracture has taken place.

Continuous traction that is efficiently applied is one of the most important aids in the treatment of fractures Many unnecessary open reductions and internal fixations can be prevented when traction is used.

## METHODS OF TRACTION

Skeletal traction may be used in many situations where open reduction would not be feasible, and its importance must be emphasized. The necessary equipment is easily available and the procedure is not difficult The Steinmann pin, the Kirschner wire, and ice tongs are the means of applying skeletal traction This furnishes an efficient, comfortable, and atraumatic means of restoring and maintaining length and alignment in fractures of long bones of both the upper and the lower extremities. The ice tongs may be used in applying traction to the supracondylar region of the femur, but the danger of the tongs slipping or cutting into the knee joint is an ever-present one. The Steinmann pin may cause ring sequestrum formation The Kirschner wire is probably the best method of skeletal traction, as the wire is small and causes less damage to the bone and the soft tissues. A special drill (Fig. 733) and a tension bow (Fig 734) are all that are necessary to apply this type of external traction

The insertion of the Kirschner wire through skin, soft tissue and bone should be done *under meticulous aseptic conditions* Local infiltration of procaine 1 per cent is usually adequate for anesthesia. The wire comes in three sizes (0.062, 0.045, and 0 035 inch) and is drilled through the bone with the special drill. The special bow is then applied to the wire so that the wire is held taut and traction is applied to the bow by means of rope over a pulley. The skin at the site of the insertion and exit of the wire can be protected with a gentian violet gauze dressing. The lower extremity is suspended in a Thomas splint with a Pearson attachment and balanced traction is maintained as shown in Fig. 735. The weight applied is maximum, and the aim should be to reduce the fracture in the first twenty-four hours of traction.

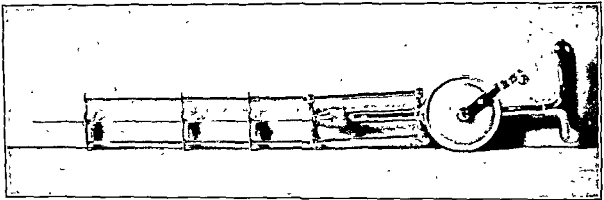


Fig. 733.—Bone drill and Kirschner wire.

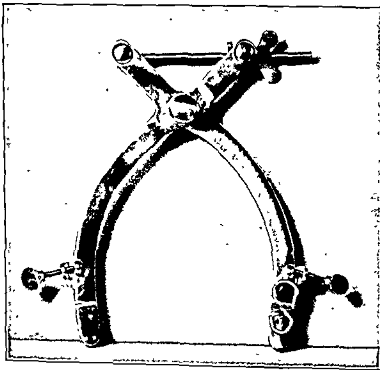


Fig 734 —Tractor for Kirschner wire.

There are a number of points where skeletal traction can be applied. For fractures of the femur the supracondylar area just proximal to the adductor tubercles may be used However, the muscles which are being pulled upon insert in the tibia, and frequently it is best to place the wire through the tibia just below the tuberosity.

Careful vigilance is required for balanced suspended traction to be successful. It not only may be used in the treatment of the femoral fractures but also in care of fractures of the metacarpals, the femur, the radius and ulna, and the tibia and fibula. It is often indicated in order to correct malalignment and overriding before open reduction is attempted. The fractures of the hip, both within and without the capsule, may be reduced by skeletal traction when manipulative methods are unsuccessful. Balanced traction is of great value in maintaining alignment and reduction in the treatment of compound fractures when internal fixation is not desirable because of the condition of the wound.

The Steinmann pin may be used for skeletal traction. It is most frequently used for traction to the femur and to the bones of the leg. It is applied according to aseptic technic. The skin is incised at the site of insertion, and with the sharp end against the bone it is either driven through the bone or drilled through the bone with a hand drill. In oblique fractures of the tibia, a method of reduction and fixation is to pass one Steinmann pin above and another below the fracture. On a Böhler frame the fracture is reduced and the reduction is maintained by incorporating the pins in a plaster of Paris cast.

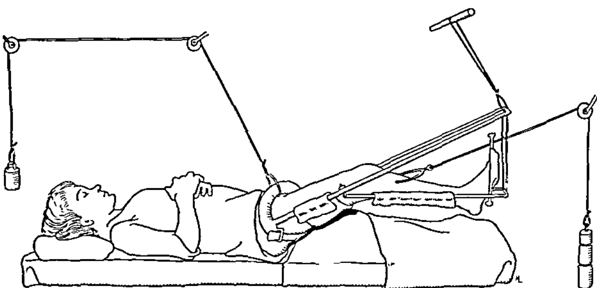


Fig. 735 —Balanced skeletal traction.

One of the most useful aids in the care of peritrochanteric and subtrochanteric fractures of the hip is the well-leg traction splint. The Roger Anderson well-leg traction splint is easily applied, and the patient is not subjected to the dangers of general anesthesia, for the Steinmann pin can be inserted under local anesthesia After its application the patient can be moved into a wheel chair and can sit upright. The traction obtained by this apparatus with abduction and internal rotation of the thigh makes possible satisfactory reduction and maintenance of this reduction. It may be adjusted with little or no discomfort to the patient while the reduction is being obtained. Because the patient can sit upright and be moved without a great deal of difficulty into the wheel chair, many of the dangers of the old abduction hip spica cast are eliminated. The principle employed in this method is that of a parallelogram by which the fracture is immobilized. The normal limb is placed in a long leg cast with the sole of the foot well padded with felt because

there will be upward pressure on this foot. On the side of the fracture a Steinmann pin in inserted through the tibia above the ankle joint 5 cm. or more. This is incorporated in a cast up to the knee and the Roger Anderson splint is applied

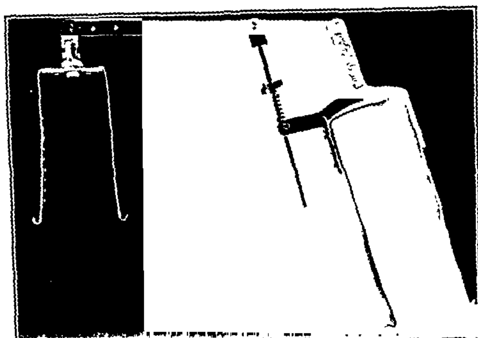


Fig 736.—Roger Anderson well-leg traction splint.

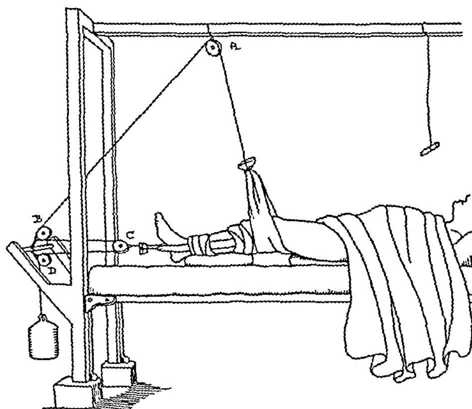



Fig 737—Russell traction for fracture of the shaft of the femur.

(Fig 736). The appliance to the well leg is fixed with plaster, and the injured side is fixed by the pin. The screw thread and spring on the injured side control the amount of traction and of rotation. This method of treatment has been a very use-

ful one and can be applied without the more elaborate equipment and experience required for internal fixation. Its greatest value lies in the treatment of the extracapsular hip fracture.

*One should not discuss the methods of traction and omit the efficient and simple method described by Russell (Fig. 737).* This form of traction is particularly useful in the treatment of fractures of the femur in children who are beyond the age for the satisfactory use of Bryant's overhead traction. It may be used to excellent advantage in impacted nondisplaced intertrochanteric hip fractures. As in every type of traction, eternal vigilance is the price of success. This traction utilizes a double system of pulleys with the pull in two directions. The *parallelogram of force produced results in a force along the line of the femur.* The position of the extremity is in a natural one. Moleskin adhesive strips are applied to the leg from the tuberosities of the tibia to beyond the heel. A Posey foot piece with a pulley is attached to the strips of moleskin. The knee is supported by a sling from which a rope passes through a pulley overhead, through another pulley at the foot of the bed, then through a pulley in the spreader at the heel, and through a last pulley at the foot of the bed to the weight. By the use of the double pulley system *only 8 or 10 pounds of weight are needed. This simple appliance can be used in the home.* The position of the fragments of the fracture can be changed by varying the angle of the cord to the knee sling.

## OPEN REDUCTION

The open reduction of a fracture consists in exposing the fracture site, direct levering of fragments to engage them, internal fixation whenever there is any doubt as to the stability of the reduction, and excision of the fragments in those fractures of the patella, olecranon, and head of the radius where there are many fragments or loose fragments of bone.

**Olecranon.**—*The triceps muscle separates the fragments when the olecranon is* fractured. Immobilization of the elbow in flexion aggravates this separation. To immobilize the elbow in extension sufficiently long enough for union would endanger its function. The method of choice is to wire the fragments together and then flex the elbow and hold this position in a plaster of Paris cast from the upper arm to the "life line," palmar flexion crease of the hand

A curved incision is made over the olecranon. The triceps tendon and fascia are reflected by sharp dissection to either side, exposing the fragments. The clots of blood and soft tissue are removed from between the fragments. A hole is drilled through the distal fragment from side to side. The fragments are approximated. A stainless steel wire is passed through the drill hole. By means of a curved needle the wire suture is carried around the *tip of the olecranon process, beneath the aponeurosis of the triceps tendon* The fragments of bone may be held in apposition with a towel clip while the wire loop is twisted tightly. The wound is closed and immobilization in flexion in a cast is carried out. If the proximal fragment is sufficiently large, a hole may be drilled through it and the wire passed through this hole.

**Patella.**—The operation should be carried out as soon as possible if the skin is in a satisfactory condition. Most of these fractures occur in automobile accidents *when the knee is violently struck against the dashboard.* The patella should be preserved unless comminution is such as to make this not feasible. Indiscriminate

patellectomy in fractures is not warranted. The fracture site is exposed through a transverse curved incision with the apex of the curve over the distal fragment. The blood clot and particles of loose bone are meticulously removed and the soft tissue is excised from between the fragments. The ruptured capsule and synovium in their lateral expansion are repaired from the lateral edge toward the midline, using interrupted No. 1 chromic catgut sutures. A circumferential loop of 0.5 mm. stainless steel wire is inserted with a large Gallic needle which is placed in close proximity to the borders of the patella above and below. The fragments are approximated and held in position by two towel clips. The wire ends are drawn tight and twisted together (Figs. 738 and 739), and the twisted ends of the wire are buried in the quadriceps tendons. The wound is closed by suturing the aponeuroses over the patella with 0 plain catgut and the skin with black silk sutures. A long cylinder circular plaster splint is applied over a sterile dressing. The patient is allowed to be on crutches after two weeks, and the crutches are discarded when muscle power has sufficiently returned In extensive comminution of the bone it may be necessary to excise completely the patella and repair the quadriceps tendon and patella ligament. The tendon and capsule should be plicated to prevent excess lengthening after removal of the patella.



Fig 738.—Fracture of patella.

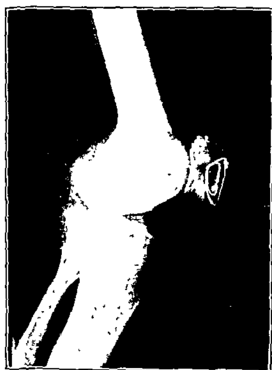
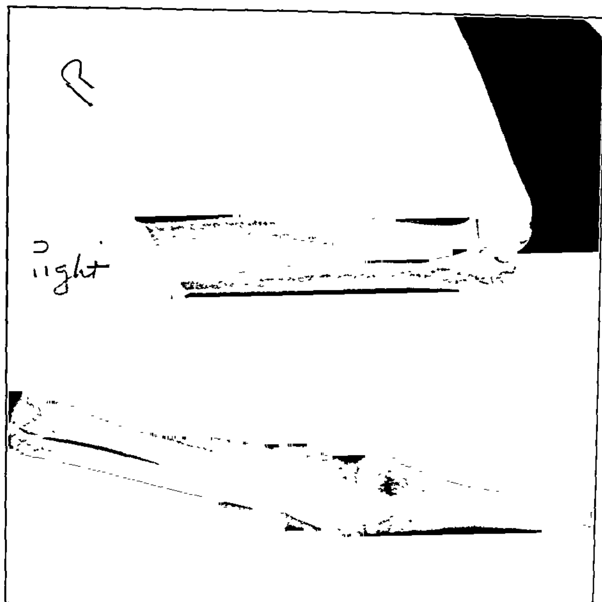


Fig. 739 —Fracture of patella after wiring.

**Medial Epicondyle of the Humerus.**—This fracture often accompanies a subluxation of the elbow resulting in the displacement of the epicondyle into the joint (Fig 740, *A*). It may be seen in the x-ray overlying the trochlea, or between the trochlea and the ulna. This fragment cannot be replaced except by direct manipulation A short curved incision is made over the medial side of the joint. The ulnar nerve is protected as the fascia is opened. The muscles and fascia that cover the medial condyle are turned into the inner side of the joint. This serves as a guide to the epicondyle which can be removed from the joint with this muscle and

fascial attachment. The fragment is then reattached to the shaft with several sutures of No. 1 chromic catgut (Fig. 740, *B*). The wound is closed and a cast is applied with the elbow flexed to a right angle.

*A.*

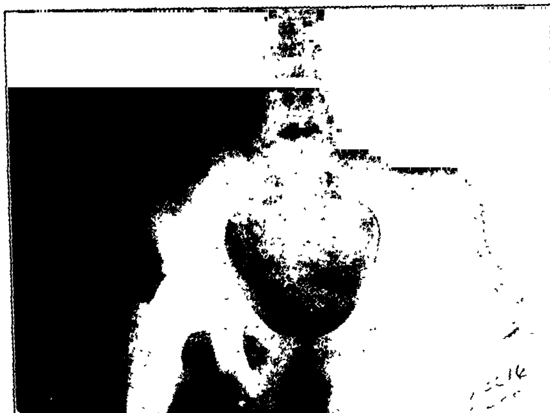



*B.*

Fig 740.—*A*, Avulsion of medial humeral epicondyle with the fragment included in the joint. *B*, Fragment replaced after open reduction, and held with chromic catgut sutures.

**Acetabular Fracture and Posterior Hip Dislocation.**—A similar problem to that just mentioned arises in fractures of the rim of the acetabulum associated with posterior dislocations of the hip. These injuries usually occur as a result of striking the knee on the instrument panel of an automobile at the time of collision. The hip is adducted and flexed making possible the dislocation and the fracture. When the closed manipulation is carried out, a fragment of the acetabular lip may be included in the joint so that complete reduction of the luxation is not possible. (Fig 741, *A*.) To leave the subluxation with the lip fragment in the acetabulum would result in poor function and inevitable degenerative changes in the joint (Fig. 741, *B* and *C*).

A.





B.

Fig 741 —A, Posterior dislocation of the left hip with a fracture of the acetabular rim. B, The fragment of the acetabulum within the joint after closed manipulation.

The posterior approach to the hip joint is relatively simple. The skin incision passes *from the posterior superior spine to the upper border of the greater trochanter,* thence along the line of the femur (Fig. 742, *A*). Along the upper border of the gluteus maximus muscle the deep fascia is incised, and this muscle is retracted posteriorly (*Fig. 742, B*). The insertion into the greater trochanter of the gluteus medius and gluteus minimus and pyriformis is divided. Retraction forward exposes the capsule of the joint in all of its aspects (Fig. 742, *C*). The head of the femur can easily be dislocated, and the lip fragments are removed from the acetabulum. The hip is reduced, the capsule is closed, and the patient is placed in a plaster of Paris cast from the rib margin to both knees. This approach seems best in the treatment of fracture dislocations of the hip, as it is almost bloodless and can be carried out rapidly. It is also useful in arthroplasty of the hip.

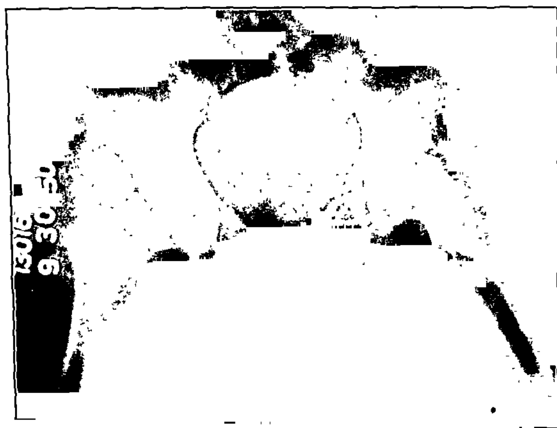
Monteggia Fracture.—This fracture may be reduced by closed manipulation, but it is impossible to prevent ulna angulation when only a cast is used. The fixation used to prevent this angulation is an intramedullary wire inserted along the shaft of the ulna. This is *done by exposing the fracture site through a 7.5 cm.* longitudinal incision, inserting the wire or Steinmann pin into the medullary cavity, and threading it across the fracture into the distal fragment. After closing the in*cision a cast is applied with the elbow at a right angle. This open operation is nec*essary when the radial head is dislocated forward and outward.

Head and Neck of Radius.—In fractures of the head of the radius in adults, if *more than one-third of the circumference is involved, and if there is tilting of the* head by a neck fracture so as to obstruct motion at the radioulnar or radiohumeral joint, the entire head should be removed. A short incision is used directly over the head of the radius along the posterolateral aspect of the elbow. The neck of the radius is exposed by carefully peeling off the supinator muscle down to the bicipital tuberosity. The neck is divided just proximal to the tuberosity and the head and neck are removed. All of the fragments of the head should be meticulously removed, and with a rongeur the sharp margins of bone are rounded off. A cuff of periosteum is laid over the raw surface, and the wound is closed after suturing the orbicularis ligament with 0 plain catgut. Active motion is started when the incision is healed. Fractures of the head and neck of the radius in children should be treated conservatively.

Neck of the Femur.—This fracture has often been thought of as the unsolved fracture. Its solution can largely be attributed to the work of Smith-Petersen, Johansson, and Wescott. The three-flanged nail of Vitallium or of stainless steel devised by Smith-Petersen was one of the greatest advances of fracture surgery (Fig. 743). The nail is the nearest answer to the treatment of the intracapsular fractures of the hip and the only contraindication to its use is the moribund condition of a patient. The nail is mechanically ideal because rotation is prevented by its flanges and angulatory movement by its length. To Wescott chief credit must be given for the method of closed reduction and insertion of the nail through a small incision accurately followed by frequent x-ray examination.

The original method of Smith-Petersen was to do an open arthrotomy of the hip, exposing the fracture before nailing was carried out. The method of extra-articular nailing as first advocated by Westcott has the advantage of not injuring the blood supply to the head of the femur which is injured by division and retraction of the joint capsule.

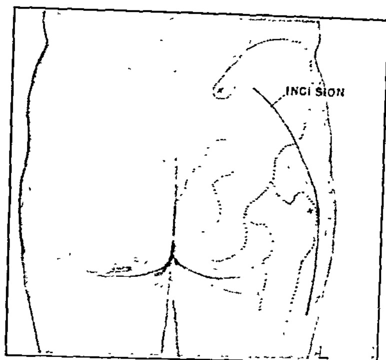
The patient is placed on an operating table with an x-ray cassette holder beneath the hip region (Fig. 744). A portable x-ray machine should be available, and also facilities for rapid film development. Usually general anesthesia is used for the operative procedure, and reduction of the hip is carried out by the technic of Leadbetter. The leg is flexed at a right angle to the thigh and the thigh is flexed at a right angle to the body. By placing the calf of the leg over the operator's shoulder the hip is lifted upward and at the same time it is internally rotated, abducted, and extended. This position is maintained by having an assistant hold the thigh in the desired position After preparing the hip region, a skin clip is placed in the skin over the femoral head at the site where the femoral artery passes beneath Poupart's ligament. This is used as a guide in nailing. Then x-rays, both anteroposterior and lateral, are taken to determine the position of the fractures (Figs. 745, 746, and 747). If the reduction is not satisfactory, remanipulation is carried out until a good position is obtained as determined by x-ray.



*C*

Fig 741, *C*.—The fragment has been removed from the acetabulum by posterior exposure of hip joint.

The length of nail to be used must be accurately determined before its insertion is attempted. The use of a guide wire that is of known length as a means of determining the length and course of the nail is to be advocated, for should the guide wire need to be extracted, it can be done without damage to the cancellous bone. After obtaining a correct position of the guide wire, the proper length cannulated nail is driven over the guide wire. The guide wire should be inserted from a spot on the lateral aspect of the femur along the linea aspera. Its position




*A.*

SUP GLUTEAL VESSELS AND NERVES

INF. GLUTEAL VESSELS AND NERVES

SCIATIC N

M. GLUTAEUS MAXIMUS

M. GLUTAEUS MEDIUS

M PIRIFORMIS

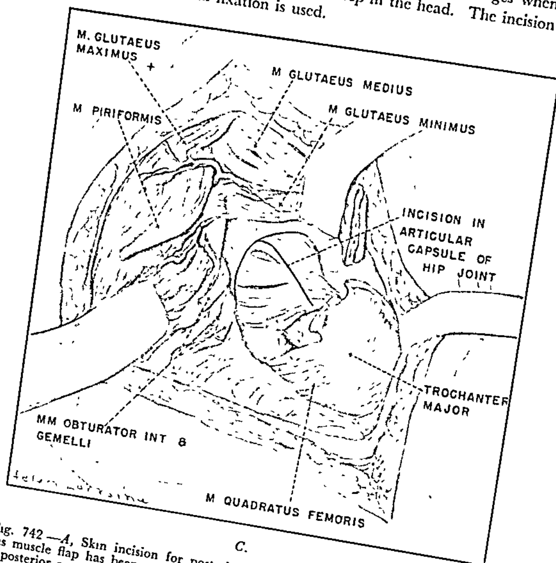
TROCHANTER MAJOR

FASCIA, ILIOTIBIAL TRACT

*B*

Fig. 742, *A* and *B*. *(For legend see opposite page.)*

is determined by anteroposterior and lateral films (Figs. 748 and 749). The lateral picture is made by putting the cassette between the thighs and pointing the tube from the outer upper side of the hip. The White driver and extractor are the only instruments needed to insert the nail (Fig. 750). If the nail is driven over the guide wire the position of which has been determined, the nail should be driven along the neck, which makes a hollow sound The pitch changes when the nail enters the solid head. The bite should be deep in the head. The incision is closed in layers, and no external fixation is used.




*C.*

Fig. 742—*A*, Skin incision for posterior approach to the hip joint. *B*, The gluteus maximus muscle flap has been retracted, exposing the sciatic nerve and short rotator muscle. *C*, The posterior capsule of the joint is incised and opened by use of a cruciate incision.

The patient may be allowed up in a wheel chair on the second postoperative day but crutch-walking should be delayed until eight weeks after the operation. Bony union as disclosed by x-rays must have taken place before weight-bearing without crutches is permitted The period required for firm union is normally six months.

Trochanteric Fractures.—This fracture differs from the intracapsular fracture in that there is a free blood supply to both sides of the fracture. Union can be expected if immobilization is carried out, but three to four months' immobilization in plaster is both dangerous and incorrect. The Jewett angle nail seems the best

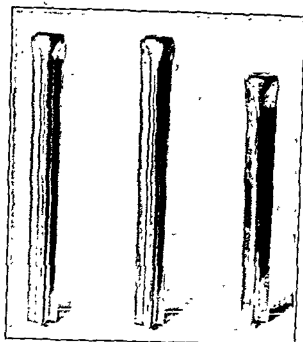


Fig. 743.—Smith-Petersen nails for fracture of hip.

Fig 744 —Portable x-ray in position with adjacent dark room.



Fig 745.



Fig. 746

Fig. 745.—Fracture of neck of femur.
Fig 746—Fracture of neck of femur, anteroposterior view after reduction



Fig. 747—Fracture of neck of femur, lateral view after reduction.



Fig. 748

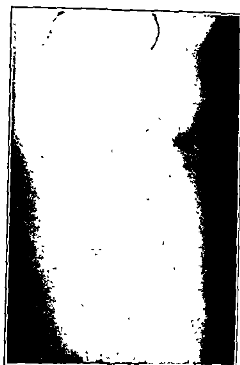


Fig 749.

Fig. 748.—Fracture of neck of femur, anteroposterior view with nail in place.
Fig 749.—Fracture of neck of femur, lateral view with nail in place.

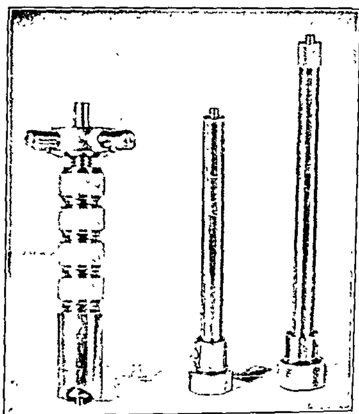


Fig 750 —White's instruments for inserting and extracting Smith-Petersen nails

method of immobilizing trochanteric fractures of the hip. This nail is a Smith-Petersen nail with a welded plate attached. The Neufeld nail and the Blount-Moore blade plates are also useful in this type of fracture. The Jewett nail is the stronger nail (Fig. 751) and is therefore advocated. The nailing operation should be done as early as the patient's condition will permit. As this is a lengthy operation with wide dissection of muscle, shock is frequently encountered. These patients should receive blood transfusion during the operation. The Thornton attachment for the Smith-Petersen nail was devised by Lawson Thornton in 1937. This was a plate attached to the Smith-Petersen nail by means of a screw. The advantages of internal fixation of trochanteric fractures far outweigh the disadvantages. The complications are far less than when a cast is used, and the function is better, particularly motion in the knees.

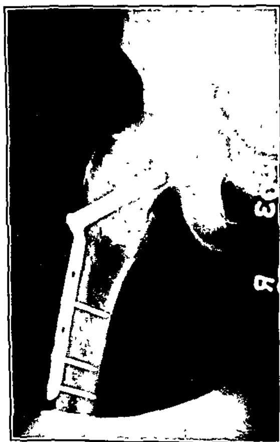



Fig. 751.—Jewett nail in place for intertrochanteric fracture.

The fracture may be reduced by either the Whitman or Leadbetter maneuver and maintained by fixation to the table. However, it seems easier in many ways to reduce the fracture under direct vision at the time of exposure before nailing By draping the extremity free reduction can be obtained by manipulation under direct vision X-ray examinations are available to determine the position of the guide pin at the time of nailing.

The fracture is exposed by a lateral thigh incision, or a Watson-Jones incision may be used. A guide pin is used to prevent unnecessary bone damage if repeated insertion of the nail should be required, as well as to eliminate considerable guesswork. The guide pin is inserted on the lateral aspect of the shaft of the femur about 2.5 cm. distal to the origin of the vastus lateralis and midway between the

anterior and posterior cortices of the femur. A drill hole is made at this point before insertion of the wire. This facilitates the "feel" of inserting the guide wire. The pin is inserted at a 45 degree angle to the shaft. X-ray examination should be made to verify the position of the pin. A Jewett nail of the needed length, usually 9.5 cm., is driven into place so that the plate is flush with the shaft. The plate is fixed to the shaft with three or more screws. The lesser trochanter fracture is disregarded. The incision is closed in layers, using 0 plain catgut for the fascia and interrupted nonabsorbable sutures for the skin. Usually no external immobilization is needed. In comminuted peritrochanteric fractures, skin traction in a Hodgen's splint may be used with 8 pounds of weight attached. The patient is permitted to be up on crutches with partial weight-bearing in twelve weeks and full weight-bearing in sixteen weeks if satisfactory union is seen in the roentgenogram.

**Intramedullary Fixation.**—The gradual development of this idea reached its most practical stage when Küntscher contributed a nail of sufficient size to make supplementary fixation unnecessary. The report, in 1940, by Gerhardt Küntscher of Kiel, Germany, on this subject gave his name to the method. In this country an effort is being made to appraise the merits of this procedure. The Committee on Fractures and Traumatic Surgery presented a report on this subject to the American Academy of Orthopaedic Surgeons, New York City, February 13, 1950. It was the conclusion of this report that this was an effective method of treating many femoral shaft fractures The limitation was, that, should the cases be improperly selected or the technic improperly carried out, more possible trouble could be encountered here than in any other method.

Intramedullary nailing seems to be most useful when limited to the care of short, oblique, or transverse fractures of the upper one-third of the femur, pathologic fractures due to metastatic carcinoma, and fractures through Paget's disease of bone, dysplasia, or extreme osteoporosis. Considerable question would be raised regarding its application in the treatment of fresh, clean compound fractures. Street recommended this method of internal fixation as the one of choice in treating suitable femoral shaft fractures. The period of disability and hospitalization is shortest and the processes of fracture healing are not significantly disturbed. The length of the nail may be estimated from the sound side, measuring from the top of the trochanter to the knee joint and deducting 4 cm therefrom. External immobilization is not necessary, thus maintaining joint motion. The complications that accompany exposure of bone are bound to occur, and it seems that one should *not undertake intramedullary nailing unless well aware of the technical difficulties* that may arise, any one of which might prove a chastening experience. The occurrence of fat emboli following the nailing have been reported. Böhler states that this has been clinically infrequent. However, minimal endosteal callus at the site of contact of the fragments with exuberant periosteal callus has been the observation of Böhler and others.

The most satisfactory nailing of the femoral shaft is by the open retrograde method. This has many advantages over the so-called blind nailing, which requires roentgenographic control. The Küntscher clover-leaf nail or the Hansen-Street diamond pin is the pin of choice. The length and diameter of the nail should be determined carefully before insertion The fracture site is exposed sufficiently to allow the fragments to be brought out of the wound This calls for a small amount of soft-tissue dissection. The patient is placed in the supine position with the af-

fected side turned up on a large sandbag. The entire extremity and hip region are prepared and draped free for necessary maneuvering. The hip is flexed 45 degrees and the thigh is adducted. The pin should be removed after union is certain. The fracture site is exposed. The upper fragment is pulled up into the wound. The proper diameter pin is selected. If the Küntscher nail is used, a guide pin is passed up the medullary canal through the supertrochanteric region of the femur. A skin incision is made adjacent to the exit of the guide pin. The nail is then driven down through the trochanteric area to the fracture site. After the guide wire is removed and the fracture is reduced, the Küntscher nail is driven into the distal fragment canal. The position is determined by x-ray (Fig. 752), and, if satisfactory, the skin is closed. The patient is allowed up on crutches after six weeks, and weight-bearing is begun after ten to twelve weeks. The nail should be removed when union of the fracture site is definite, usually in eight to twelve months.




Fig. 752.—*A*, Fracture of the upper third of the femoral shaft. *B*, The Küntscher nail is in place, with exuberant callus.

## COMPOUND FRACTURES

This term indicates the necessity for surgical intervention The complicating factor in the care of this type of fracture is the danger of infection, and gas gangrene is a grave danger. Osteomyelitis with its long-drawn-out course of treatment is a dreaded possibility.

The ideal result is union and function without infection. To accomplish this, the treatment should begin at the earliest possible moment, for the wound is con-

taminated and time is a big factor in lessening the chance of gross infection of the soft tissues and bone. If the delay is longer than six hours, it is generally agreed that massive infection is likely to occur, so that after this time has elapsed, the wound is considered infected, for the bacteria have begun to grow in the tissues. The treatment of a compound fracture should begin at the place of the accident. The wounds should be dressed with a pressure bandage and a splint applied before transportation to the nearest hospital.

From the time the patient is first seen in the hospital, the one aim in treatment should be to prevent the contaminated wound from becoming an infected one. The compound fracture is an acute emergency and must be treated accordingly. The mask over the mouth and nose should be worn when inspecting the wound, and the wound should be covered with a sterile pressure bandage. The patient's general condition should be rapidly surveyed. The presence or imminence of shock should be immediately recognized and treatment instituted. The patient should receive tetanus antitoxin and possibly gas gangrene antitoxin after a negative skin test for anaphylaxis. A prophylactic dose of 100,000 units of aqueous penicillin should be given during this time when the survey of the patient is being made prior to definitive surgery. Portable x-rays should be obtained if indicated, moving the patient as little as possible and only when the fracture is splinted.

As soon as the patient is prepared for surgery, the treatment should be carried out in the operating room The local care of the wound consists of carefully washing the skin with soap and water and shaving the area near the wound. The skin can then be cleaned with a preparation such as Mercresin, avoiding its entrance into the open wound. The area is surgically draped, and the wound is cleaned with an abundance of normal saline while the débridement is carried out. The skin margins are débrided carefully and all foreign-body material is removed. The devitalized fascia and muscle are carefully and sharply excised. The skin wound should be sufficiently enlarged to provide ample exposure for débridement and cleansing the underlying structures Severed tendons and nerves should be sutured, and all loose fragments of bone removed The bone ends should be cleaned, if needed, by removal of the edges with a rongeur. The use of internal fixation in a compound fracture is not the treatment of choice. It may be a necessity and the chance of success is enhanced by the antibiotics, but still it introduces an irritant factor into a contaminated wound. The fracture is reduced and the fragments locked or held in the best possible alignment. This reduction is maintained by skeletal traction by means of a Kirschner wire, which is inserted well away from the potentially infected area There is no occasion for the introduction of internal fixation into a draining wound. The skin should be loosely approximated, no tension closure being desirable, and no buried sutures are used except for tendon and nerve suturing The skin closure is usually safe if the fracture is operated upon within the first six hours after the injury but experience and judgment alone should be the deciding factor as to the question of skin closure. If closure is carried out, no buried sutures are used and the interrupted nonabsorbable skin sutures are placed far enough apart to allow for drainage by seepage but no actual drain is used. In cases where skin closure is under too great tension, relaxing incisions may be made in line with the wound and 5 to 7.5 cm. away from the wound. This will permit closure over the bone and the fresh wound will heal by granulation.

There is a difference between the civilian injury and battle casualty in that the wounds of battle are due to missiles, are more extensive, and there is delay in treat-

ment. Secondary suturing under these conditions seemed the best procedure. The wound is packed lightly with petrolatum gauze and is closed with interrupted nonabsorbable sutures on the fourth to seventh postoperative day. If gross infection develops, the wound may be permitted to heal by granulation. The old and infected compound fractures may be treated by this method.

The proper care of compound fractures with small lacerations or puncture wounds is most important. The tendency is to douse the wound with an antiseptic and treat the fracture as a closed fracture. This is dangerous and should not be done. The most satisfactory method is to enlarge and débride the wound to its depth. Unless this is done, a perfect medium for bacteria may be left beneath the skin. The possibility of tetanus or gas gangrene resulting from failure to débride thoroughly is not to be forgotten. These wounds may be primarily left open and, if no infection occurs, secondarily sutured four to five days later.

Antibiotics started in the emergency room are continued until one is fairly certain that the patient has no infection that his body cannot control. The wounds should be dressed infrequently. Even though pus be present, the wound should not be disturbed.

If the compound fracture becomes infected, the fracture should be permitted to heal. This will occur even in the face of an osteomyelitis, and sequestra are left alone until the fracture site has been bridged by callus.

The antigas-gangrene serum should be given along with penicillin as prophylactic therapy Gas gangrene may occur in spite of all care, and its prompt and early recognition may be lifesaving, for its occurrence calls for early vigorous action. The patient has excessive pain, high fever, a rapid pulse, and appears ill. The wound should be opened with wide incisions, and smear and culture studies for the gas bacillus made. Gas bubbles may be felt in the soft tissue, accompanied by marked swelling. A characteristic odor of gas is often present. Wide incisions with excision of muscle that does not bleed or retract, antibiotics in large doses, gas antitoxin, and x-ray therapy may prevent amputation Amputation may be necessary, and this calls for rare surgical judgment. These wounds should be left open, and failure to prevent spread of the infection and increasing toxemia demand amputation

## NONUNION

There is no timetable by which one can say that nonunion exists in a fracture. When union has not taken place in the average length of time, one may ascribe the term, delayed union. Fracture healing is not according to the calendar, so whatever the passage of time, this does not mean nonunion

When bony union is obviously impossible, as shown clinically or roentgenographically by cessation of the process of repair, nonunion of the fracture should be considered as existing. The fracture surfaces are smooth and sclerosed. Dense fibrous tissue joins the fragments and a false joint may develop at the site

There are a number of etiologic factors in the production of this failure of union. The most important one is the failure to immobilize the fracture adequately. Failure to obtain a proper reduction is another important cause. After a fracture has been reduced, complete, uninterrupted, persistent immobilization should be the rule. Each time the cast or splint is changed before union has taken place, any twisting or shearing motion at the site of the fracture may cause damage to the

healing tissue, resulting in the formation of large amounts of cartilage. If motion persists, the cartilaginous callus is replaced by fibrous tissue which will not revert to bone; hence the nonunion.

Constitutional causes play an unimportant part in nonunion. Multiple fractures with comminution, so often seen as a result of automobile collisions, frequently result in nonunion of one or more of the fractured bones. The excess demand for bone production may be too great; and the limit of the organism to produce callus is reached. Perhaps the only answer to this would be a constitutional one.

Compound fractures, infected fractures, marked damage to the soft tissue, interposition of soft parts, distraction of the fragments, and impairment of blood supply are factors in the production of ununited fractures. Each of these conditions contributes to nonunion by interfering with the blood supply and the process of repair.

When the bone ends are sealed across with bone that appears the same as the cortex, and between these sealed fragment ends there is fibrous tissue, operative intervention is indicated in order that the process of granulation tissue growth might be initiated again.

The problem often arises regarding the treatment of old infected fractures resulting in nonunion. Frequently it is advocated that twelve months should elapse after drainage has stopped. Two-stage operations have proved helpful. Cleaning the bed and freshening the bones are done at the first stage. After several weeks the graft is completed if infection has not flared up. Failure to immobilize adequately, rather than the infection, is the main cause of nonunion. A recurrence of the infection does not indicate that a successful result is impossible. Living organisms may remain in the interstices and bone recesses the rest of the patient's life. A bone graft should never be used in the presence of drainage. Every effort should be made, by using antibiotics, to prevent a flare-up. If it does recur, the wound should be drained and the graft left in place with immobilization maintained

The idea in treatment of nonunion is to produce a fresh fracture so that union may be brought about by the physiologic processes of normal repair. As a stimulant of this process the bone graft is used. It also serves as an internal splint, aiding in immobilizing the fracture and serves as a scaffold for the growth of new bone. The same principles hold here in the protection and maintenance of alignment as in the fresh fracture.

## Bone Grafting

Albee, Henderson, Campbell, and others are responsible for the introduction of bone grafting for osteogenesis. Venable and Stuck introduced fixation by inert metal. The combination of these two principles has proved a tremendous boon. In addition to these, the bone bank, with its advantages, has facilitated the treatment of nonunion.

The fate of the bone graft has been well presented in the studies of Abbott and others. They have shown that the mature bone elements are removed by creeping substitution. The endosteal cells are the ones that produce osteogenesis This is true of the cambium layer of the periosteum, except to a less degree. The difference in the cancellous and cortical bone as a graft lies in the greater endosteal cell elements in the former with the numerous marrow spaces. These spaces allow more rapid revascularization, thereby greater survival of endosteal cells The cortical

bone serves more as a splint and a scaffold. The cancellous bone has greater osteogenetic powers. Therefore, the purpose of the graft determines the choice of one or the other; usually both cancellous and cortical bone grafts are preferable.

Bone grafts as used are autogenous or homogenous. Heterogenous bone grafts are used very little at the present time. They may be principally cortical bone or cancellous bone and the grafts may be used as massive ones, or as chips or ribbons. The periosteum may be used with the cortical and cancellous bone. However, the periosteum, since it appears of little advantage, may be left in place to close over the site of the removal of the graft. Those conditions requiring large grafts for immobilization and filling of gaps would indicate the use of the massive graft. The autogenous graft may best be taken from the tibia or ilium or fibula. The homogenous graft is now available by means of the bone bank or a donor. The donor need not be of the same Rh or blood type. This source of homogenous bone has proved a great help in reconstructive surgery. There is little evidence to show that this type of graft is less efficient than the autogenous Since the bone can be secured from amputations and from procedures where ribs are removed, and then stored, the problem of obtaining this material has been simplified. One still has the feeling that a living autogenous bone is to be desired over the frozen homogenous graft.

The work of John Royal Moore in delayed bone graft, as especially applied to pseudarthrosis, should be considered in the treatment of previous bone grafting procedures that have failed to obtain union In this procedure the fracture site is exposed, the scar from the skin, fascia, and muscle is carefully excised, and the fibrous tissue between the fragments is excised. The bone ends are left freshened, and the wound is closed. At this first-stage operation, the site of the autogenous bone graft is exposed and the graft of the desired length and shape and width is cut with the electric saw This is lifted from its bed and then replaced. The second stage of the operation is delayed for ten days or two weeks. This stage requires less time because of the major preparation during the first stage. The graft is removed easily from its bed and the site of grafting is exposed through the previous incision and then fixed by the desired method. Though this idea was mainly for tibial pseudarthrosis, it is to be highly recommended in the problems of failure with previous bone grafting for nonunion. Perhaps the local changes of the phosphatase activity may be a deciding factor in the success of this procedure.

After deciding upon the kind of graft to be used, the actual procedure may vary The skin incision, as in all surgical approaches, should be adequate to allow for excision of all scar tissue in skin and bone. One aims to have a bleeding fresh bed for the graft The sclerosed bone may be drilled or removed with an osteotome so that bleeding bone is obtained. The type of graft used may be an "onlay" one or it may be inlaid into the host bone. In most cases the massive onlay bone graft for nonunion is preferred. The bed for the onlay graft is prepared by elevating a layer of bone with an osteotome from each fragment of the host bone. The area prepared on each fragment is three times the length of the defect between the fragments.

If an autogenous graft is to be used, this may be prepared by a second team in order to shorten the time of operation. The inner surface of the tibia is the most satisfactory site for obtaining the graft. A curved incision is made along the anterior medial surface of the tibia with the convexity to the medial side. The periosteum is incised sufficiently long in order to remove the graft. The periosteum is reflected medially and laterally with a sharp osteotome. The size and shape of the

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graft desired is outlined. The oscillating bone saw is the ideal instrument for removing this graft, as its safety is of tremendous value for there is no rotating blade to cut the soft tissue, or the assistant, if the instrument should slip. The graft can be cut to any desired shape or length. It is removed from the bed and the donor site is closed by suturing the periosteum over the defect, using a continuous 0 chromic catgut suture. The subcutaneous fascia is closed with 00 plain catgut sutures. The skin is closed with a continuous nonabsorbable suture. A short leg cast is applied over the sterile dressing. This cast should be worn for four weeks to obviate the danger of a fracture at the donor site.

The ilium is the site, other than the tibia, most suited for removal of grafts. The incision to expose the ilium is made along its subcutaneous area and carried down to bone, and then subperiosteal dissection is done. Both cortices may be removed, if desired, or only the outer. The sliver graft is removed with a thin sharp osteotome. The cancellous bone can be removed with a large curette. The wound is closed by approximating the periosteum with chromic catgut sutures. This is an excellent source of bone, especially when the graft is used in a spinal fusion operation.

The graft is placed in the prepared bed. The onlay graft is held across the host site with a suitable clamp, such as the Lowman clamp. Then drill holes of the desired diameter, preferably six in number, are made and the Callison screw is placed through the graft and opposite cortex of the host bone. This method of internal fixation of the graft is almost routinely used in onlay grafting, and frequently with the inlay graft. Fixation accomplished, the wound is closed. Cancellous bone chips are placed about the fracture site at the time of the onlay graft. Over a sterile dressing of gauze and sheet wadding a plaster-of-Paris cast is applied, including the joints above and below the operation. This fixation should be uninterrupted until union is complete, and if possible, the cast should not be split unless circulatory embarrassment occurs. As a rule, union takes place in three to four months, requiring two to three times the length of time for the union of a fresh fracture. The external fixation is continued until there is firm union as disclosed by x-ray In the lower extremity, after good union is shown, weight-bearing should be protected by a Thomas knee splint or walking iron in the cast. This is done to insure no refracturing.

An excellent method of holding the graft in place while drilling the holes is used by Bennett. Because of the chance for the graft to slip and throw off the drill holes, fixation must be absolute. The use of several Parham bands will accomplish this fixation. The bands are removed before closing.

In nonunion of the humerus, this complication may be overcome by changing the transverse fracture into a long oblique fracture. The slight shortening that occurs is a minor matter. The oblique fracture may be held with a transfixing screw. Cancellous bone is best packed about the fracture site before closing. However, if much sclerosis is present with wide separation of the fragments, the massive onlay bone graft is probably to be desired.

**Bone Graft for Ununited Fracture of Carpal Scaphoid.**—This fracture is frequently overlooked It is often diagnosed as a sprain X-ray films in three planes should be made when a carpal scaphoid fracture is at all suspected. Fractures of the wrist and proximal pole of the carpal scaphoid practically never unite unless there is adequate fixation. Drilling the fragments in nonunion is not satisfactory

Excision of the entire scaphoid bone or of the proximal row of carpal bones is rarely justified. The ulna fragment, if less than one-third of the scaphoid bone, may be excised, with likelihood of a satisfactory result. The method of bone grafting used by Soto-Hall and Holderman has advantages. An incision is made laterally over the wrist. The incision lies between the dorsal and palmar surfaces and is 7.5 cm. in length (Fig. 753). The radial styloid is the landmark, and when it is exposed the fracture may be found just distal to this prominence. The joint capsule is opened transversely to the fracture line A drill hole is made 5/16 inch in diameter through the fragments (Fig. 754). A bone peg, slightly larger than the drill hole,

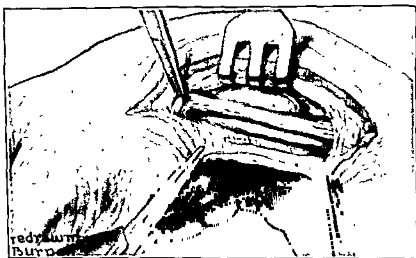


Fig 753.—Incision to expose fractured carpal scaphoid.

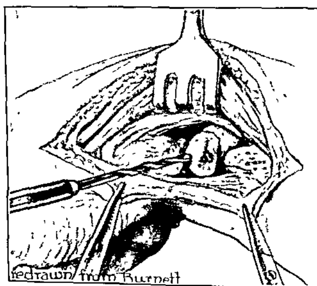



Fig 754.—Drill entering distal fragment of carpal scaphoid

may be removed from the distal radius, and the graft is driven through the drill hole across the fracture site (Figs. 755 and 756). The wound is closed in layers and the fracture is then immobilized in a cast. Eighty-five to ninety per cent of fractures of the carpal scaphoid bone recognized early and properly treated will unite satisfactorily. The immobilization in plaster should extend from the upper third of the forearm to the metacarpal neck, with the hand in slight dorsal flexion and radial deviation. The thumb to the middle of the nail should be included in plaster, with

its base in full abduction. Until union is solid, this fixation should be continued. Murray, in 1946, reported ninety-six cases uniting from the technic above, which he described in 1934.

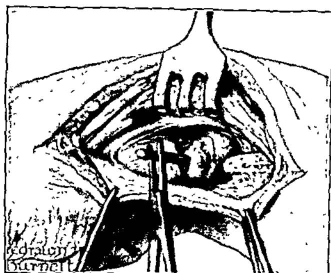


Fig. 755.—Bone peg from tibia is put into drill hole.

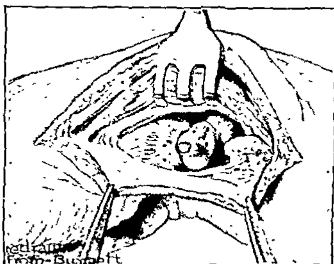


Fig. 756.—Pegging completed.

## RECONSTRUCTION OPERATIONS OF THE HIP

The use of the Smith-Petersen nail for fractures of the neck of the femur has lessened greatly the necessity for reconstruction operations of the hip. Before the use of this nail, union by fibrous tissue was so frequent that osseous union was thought not to occur. Nonunion occurs more often in fractures of the neck of the femur than in any other bone. The disturbance to blood supply of the head of the femur by a fracture leads to nonunion and aseptic necrosis of the head. The nail has solved only partially the problem of this fracture.

The patient with nonunion or fibrous union of the neck of the femur is an invalid. Crutches are required for walking, as the limp from the instability due to the nonunion prohibits walking without this ai[d] ... condition of pain and instability can be relieved in 6 ... 75 per cent ... in which it occurs. The method of treatment de... the viabilit... d.

If the patient is seen by the surgeon when the head is viable, an osteosynthesis as described by Albee may be used. In his operation a large tibial graft is placed in a drill hole through the trochanter neck and head. If the head is not viable, or if there is a question as to viability, a "reconstruction operation" is the one to be considered. The Whitman reconstruction operation (Figs. 757-760) offers hope for relief. The head is removed and the neck is inserted into the acetabulum to provide support. If the neck has been absorbed, the Colonna operation (Fig. 761) should be used instead of the Whitman reconstruction.

A U-shaped incision is made, beginning 2.5 cm. behind the anterior superior spine, running downward and backward, and crossing the femur 7.5 cm. below the apex of the greater trochanter (Fig. 757). The interspace between the tensor fasciae and gluteus medius is defined as one proceeds by blunt dissection toward the joint. After opening the capsule, the head of the femur is removed (Fig. 758). The anterior margin of the gluteus minimus is now followed to its insertion at the greater trochanter and at this point the base of the trochanter is cut through in line with the axis of the neck (Fig. 759). This flap of bone and muscle is then turned upward and the entire upper extremity of the femur is freed from all soft tissue. After the loose head has been removed, the remaining neck of the femur is thrust into the acetabulum and is held there in 25 degree abduction (Fig. 760). Then the flap, consisting of the greater trochanter and the muscle attached to it, is pulled downward as far as possible After a bed is made in the shaft of the femur at the appropriate level by chiseling through its cortical layer, the trochanter is imbedded in it and fastened by screws or drill hole sutures. The wound is closed in layers and a long spica is applied with the limb extended and abducted. After four weeks the cast is bivalved, and motion, massage, and baking are started. Usually weight-bearing is safe eight or ten weeks after operation.

If the femoral neck has been completely absorbed, Colonna's operation is preferable. A similar incision is made, crossing the femur 12.5 cm. below the tip of the greater trochanter (Fig. 761). The fascia is divided, and all the muscles attached to the greater trochanter are carefully cut near their insertion, care being taken not to remove any portion of the underlying bone but to leave the upper extremity of the femur covered by a thin layer of muscle and fibrous tissue.

The capsule is then opened longitudinally, after which it is divided transversely close to the greater trochanter, in order to preserve as much of the capsule as possible. After rotating the limb outward and adducting it, the upper extremity of the femur is freed by sectioning the gemelli, piriformis, and obturators close to their insertion (Fig. 762). The femoral head is removed, and if any spicules of the neck fragment remain, they are chiseled off flush with the inner portion of the shaft. This raw area is covered over with adjacent tissue. After the greater trochanter has been completely freed of all its muscular attachments, the limb can be pulled down and the trochanter placed deeply into the acetabulum. The thickened capsule and abductor muscles are pulled down, holding the limb in about 20 degree abduction. The fibers of the vastus lateralis are then separated subperiosteally, exposing the shaft of the femur. A bony trough is made on the lateral aspect as far as the abductor muscles (removed from the greater trochanter) will reach, when the limb is in about 20 degree abduction (Fig 763). Before preparing the bony flap in the shaft of the femur, care is taken to have the patella pointing forward. The muscles are drawn down snugly to the bony trough and sutured here with

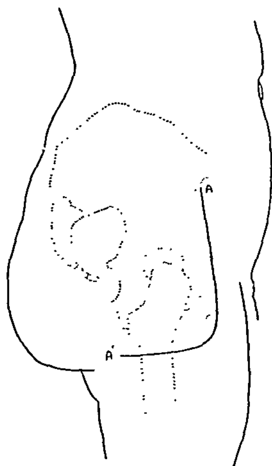



Fig 757.

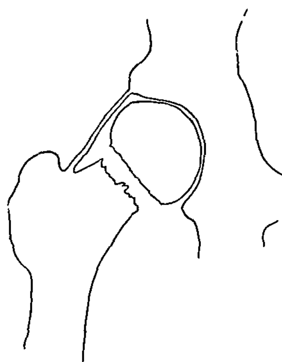


Fig. 758.

Fig. 757.—Whitman's reconstruction operation on the hip *A-A'*, Incision.
Fig 758.—Whitman's reconstruction operation showing the ununited fracture.

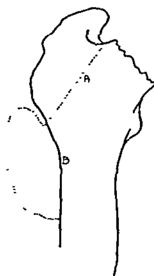



Fig. 759

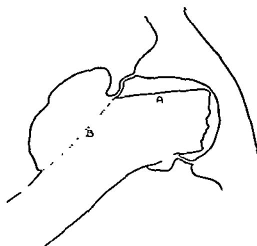



Fig 760

Fig 759—Whitman's reconstruction operation The line of incision through base of great trochanter and the site to which trochanter is transposed

Fig. 760—Whitman's reconstruction operation The remaining femoral neck has been placed in the acetabulum and the trochanter *transplanted downward on outer surface of the* shaft of the femur

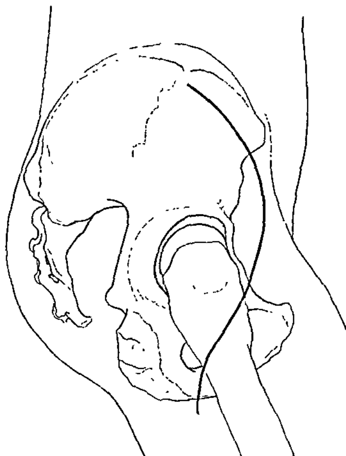


Fig. 761.—Showing the type of skin incision. Colonna's operation

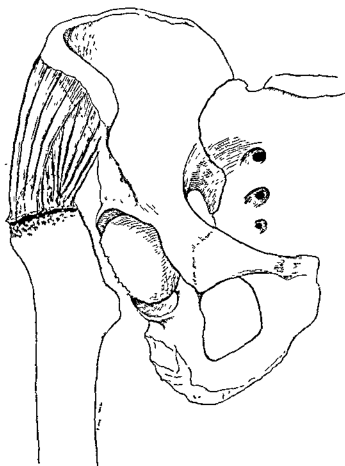


Fig. 762.—Colonna's operation Showing the cutting of the muscles attached to the greater trochanter, leaving fibromuscular tissue covering the bone. The capsule is cut through and the loose fragment of the head is removed.

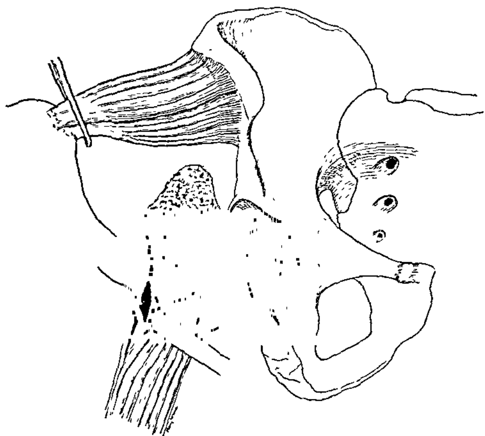


Fig 763.—Colonna's operation. The abductor muscles are turned upward. A canal is made on the lateral aspect of the shaft of the femur, and kangaroo tendons are threaded through as shown




Fig 764.—Colonna's operation. The femur is pulled down and the upper extremity is placed deeply in the acetabulum The abductor muscles are sutured in place as shown in *A*. The fibers of the vastus lateralis are reefed over the transplanted muscles, holding the flap of bone firmly in place, as shown in *B*.

kangaroo tendon passed through drill holes, and the bony flap is sutured over the mass (Fig. 764). The vastus lateralis is carefully reefed over the new insertion of the gluteus muscles and the wound is closed in layers. The after treatment is the same as after Whitman's operation.

### Schanz Osteotomy of the Femur

The indications for this operation are (1) disability due to instability of the hip, which may be accompanied by varying degrees of pain and fatigue, and (2) those cases of delayed union or nonunion of fracture of the neck of the femur with coxa vara deformity in which there is still a chance to effect a union by relieving the shearing force present.

Schanz states: ". . . through the angulation of the neck, the fracture site is placed below the head (of the femur) and the body weight no longer pushes the head downward past the fracture surface but directly against. This provides more favorable weight-bearing relations and may even lead to late bony union."

Schumm divides his cases into two classes: (1) cases in which an insidiously developing coxa vara indicates a prospective nonunion, and (2) cases of definite nonunion with absorption of the neck, in which there is a marked upward riding of the shaft, so that the fracture surfaces have slid by each other. This classification is a guide to the site for osteotomy. In the first group, the osteotomy is placed just above the lesser trochanter or as near to the lesser trochanter as possible and is called the high osteotomy; whereas, in the second, it is placed several centimeters lower and is called the low osteotomy.

As Schanz pointed out, an anteroposterior roentgenogram, taken with the affected leg in maximal adduction, is of importance in determining the degree of angulation desired, and in the low osteotomy is of help in locating definitely the site. The angle corresponds to that formed by the upper portion of the adducted shaft and the long axis of the body. In the low osteotomy this angle varies between 35 and 60 degrees. In the high osteotomy the angle should be somewhat greater, varying between 45 and 70 degrees. The site for the low osteotomy is at the point of closest approximation of the shadow of the shaft to the pelvic rim, which is usually at the distal end of the tuberosity of the ischium.

With the patient on a fracture table and the affected hip elevated by a sandbag, a lateral incision is made, centering over the site selected for the osteotomy. With the femur exposed, holes are drilled through the shaft into which the special Schanz screws are placed. One hole is drilled above and one below the site of the proposed osteotomy, leaving a minimal working space of at least 5 cm. between the holes. Instead of drilling at right angles to the shaft, as Schanz suggests, Schumm prefers Riedel's modification of drilling obliquely at the desired angles, so that, when the screws are inserted and then brought parallel, the fragments are in the desired position. A protractor, or a piece of stiff tin foil cut to the desired angles, is used as a guide for the drill holes. It is preferable that the angle of the hole in the upper fragment be approximately one-third of the total angle desired and that the angle of the hole in the lower fragment be the remainder (Figs. 765 and 766).

After the screws have been inserted, and not before, the femur is divided. In the high osteotomy, a wedged osteotomy with the base on the lateral aspect is desirable, but in the low a modified transverse osteotomy is more efficient. This modification consists of leaving a projecting tongue extending upward on the lateral

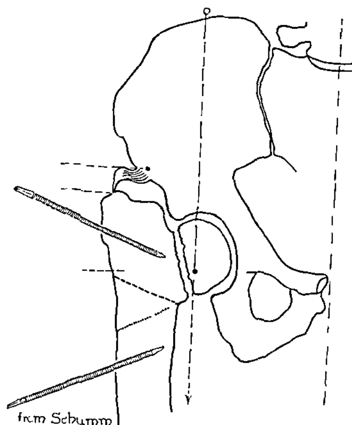



Fig. 765 —Schanz osteotomy. Schanz screws in place and lines of osteotomy

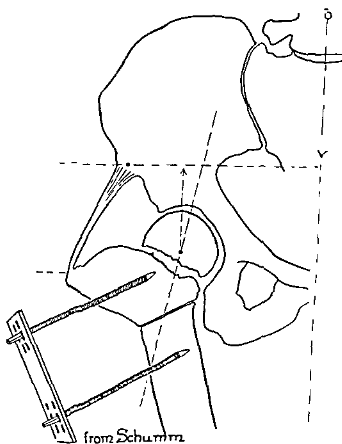



Fig. 766 —Schanz osteotomy Position after completion of osteotomy and placing of Riedel plate.

aspect of the lower fragment, which engages in the medullary cavity of the upper fragment, thus assisting to hold the fragments in position. By dividing the mesial half of the shaft first, one can help prevent splintering of the shaft, which is occasionally experienced when doing an osteotomy on older persons. The wound is then closed in layers, the screw ends projecting from the incision. To hold the desired angle, the screw ends are securely fixed by attaching a Riedel plate. A large plaster spica is applied, including the well leg down to the knee.

As soon as the patient is comfortable and the cast has thoroughly dried, a window is cut out over the knee to allow passive motion of the patella and gentle massage. At the end of six weeks, through a second window exposing the incision, the sutures and screws are removed. A checkup x-ray picture is taken at the end of the first week. At the end of the eighth week, the cast is removed and another checkup roentgenogram is taken, and, if the condition appears favorable, the patient is allowed up on crutches.

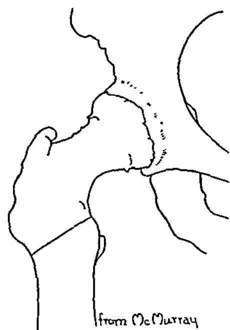



Fig. 767.

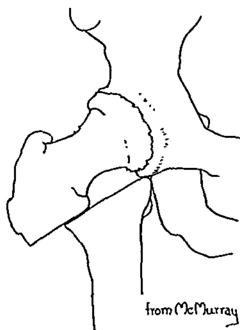



Fig. 768

Fig 767.—McMurray's site for osteotomy of femur.

Fig 768—Position of upper end of shaft after completion of McMurray's osteotomy of femur.

McMurray performs a similar osteotomy without the use of Schanz screws. He has reported excellent results in the treatment of osteoarthritis of the hip by this method.

The femur is approached through a 15 cm vertical incision on the outer side of the upper portion of the shaft. After the muscle attachments have been cleared from the front of the shaft and the neck of the femur, so that the exact relationship may be appreciated, the bone is divided in an oblique line at an angle of 40 degrees, so planned that the upper end of the osteotomy lies between the lesser trochanter and the neck. The osteotomy must be complete, so that splintering does not occur. After the two fragments are separated, the lower fragment is displaced inward until its upper margin lies directly under the cotyloid ligament of the hip joint (Figs. 767 and 768). At first, a gap is left between the divided surfaces of the two fragments,

but gradually this space becomes obliterated by the rotation inward of the lo
end of the upper fragment, which is pulled in this direction by the muscles w
have a common attachment to both fragments.

The fracture is then treated by fixation of the hip, thigh, and leg in a
plaster spica, with the limb in 20 degrees of abduction, and with the knee and
flexed to 25 degrees, thereby preventing any strain on either joint. After two
one-half weeks, the cast is changed and the limb is fixed in a neutral position
slight flexion of the hip and knee. This point of fixation of the limb in the neu
position during the period of union is very important. If the limb is fixed in
slight abduction, an ugly knock-knee deformity develops after removal of the
Fixation is continued until bony union is complete.

The difficulty of controlling the fragments in the Schanz osteotomy wa
chief objection. Blount introduced a double-angle blade plate for internal fixat
This eliminated the necessity for fixation in a cast. By a lateral incision the
chanter and upper shaft of the femur are exposed. An osteotomy is done at
lower edge of the lesser trochanter, after a gooseneck nail is inserted into the
chanter at the desired angle. If this angle is not correct, the blade plate can
easily changed with bending irons The osteotomy is completed by placing a
periosteal elevator around the medial side of the femur at the lesser trochanter,
aiming the cut with the osteotome to this site. The distal fragment is then abduc
to the plate of the nail and fixed there with screws across both cortices. The
tient is allowed up in a wheel chair early, and on crutches in eight weeks T
operation, as a rule, required no external fixation in the way of casting. Beca
of this fact it obviates a good many difficulties that arise when a cast must be appli

## LEG LENGTH EQUALIZATION

The difference in leg length results from shortening of one side or from ov
growth on the opposite side Many conditions may give rise to this differen
Epiphyseal injuries, anterior poliomyelitis, congenital anomalies, congenital hyp
trophy, vascular abnormalities, as in the arteriovenous aneurism, inflammato
lesions adjacent to the epiphysis, neurofibromatosis and fractures of the femo
shaft, may lead to one or the other of the conditions giving the discrepancy in l
length.

This inequality may be both a psychic and a physical handicap. A limp
caused. The short leg is overstrained. The spine and pelvis are deformed. Wh
only 1 to 2 cm. shortening exists, this is best handled by elevating the heel on t
short side. The heel lift may be done by taking one-half of the difference fro
the heel of the shoe of the longest side and adding the remaining half as a lift to t
shorter side. When the difference is 3 cm or more, equalization operations shou
be considered To equalize leg length the short extremity may be lengthened or t
longer one may be shortened. In children epiphyseal arrest probably offers t
most satisfactory method of overcoming discrepancies of leg length. Here, mentio
should be made of lumbar sympathectomy in the treatment of this problem. T
conclusion of Barr, Stinchfield, and Reidy was this method of Harris and McDona
can be used in minor discrepancies of limb length but is probably best supplemente
or supplanted by other methods if there is discrepancy of any magnitude

An osteotomy of the femur may be done to shorten the normal extremity. Th
advantages of this operation are that it is easier on the patient and on the operato

it is done at one time; union occurs in a short time; and no special equipment is required. The risk of a complicated operation on an already damaged extremity in leg lengthening is more formidable than in leg shortening. However, the latter must be considered a major procedure. The total stature is reduced by the shortening operation. The stimulus to growth induced by improved function, if the osteotomy is done during the growth period, may lead to overgrowth of the previously short extremity.

### Leg Lengthening by Skeletal Distraction of Tibia

The advantage of this operation is that the patient's total height is not decreased It is an operation of magnitude and special apparatus is required. Long-continued traction and fixation and the increased chance of infection or of non-union are some of its difficulties. The procedure and apparatus of Abbott should be used. This method has proved to be consistently successful, and there are a minimal number of complications.

A tourniquet is used, and the Achilles tendon lengthening is done by an inverted "L" incision to maintain continuity of tendon tissue. If further dorsiflexion of the foot is needed, the deep layer of the crural fascia underneath is divided vertically.

Four pins or wires are inserted through the tibia by a drill guide. In inserting these pins, two should go through the upper metaphysis and two through the lower, the pins being 2.5 cm. apart (Fig. 769). The skin should be retracted as firmly as possible toward the center of the leg to allow for the stretching required during the later lengthening. As the skin has been retracted toward the center of the leg, the drill guide is placed firmly against the skin with the templet of the guide parallel with the sagittal plane of the tibia and not with the leg. The guides themselves should be pushed through the templet until they are in contact with the skin. Pressure then applied will mark the skin at the point of contact with the guides Tiny stab incisions can be made through the skin at the marks left by the guides. It is well to note that the guide should be always held on the inner and not the outer side of the leg. The guide is again placed on the leg with the skin retracted toward its center and a drill hole is placed through the lower guide. A pin placed through this guide and hole can be forced through the anterior muscle bundle of the leg and a nick in the skin is made over the end of the pin and it is pushed through. When this pin is in place, the apparatus will be well stabilized for setting the other pins The second of the distal pins can be placed in similar fashion. It is extremely important when placing the third pin of the series which is next to the top that the drill guide be sprung forward 0.5 cm. on the lower two pins before drilling. This third hole is drilled but no pin is placed through it until after the fourth pin has been drilled for, put in position, and the drill guide removed. Then the third pin can be driven into place and the fifth pin placed through the os calcis. In the use of Kirschner wire, the same procedure is followed, the wires being drilled through directly. The reason for the offset third pin is to provide for forcible maintenance of contact of the tibial fragments following osteotomy, thus preventing anterior bowing. Dressings wrung out of Dakin's solution can be placed over the ends of the pins before the next step is taken.

Through an anteromedial incision, the tibial shaft is exposed in the central area and by motor saw its cortex is cut through near the internal border and on

the lateral surface. These saw cuts are joined below by a transverse cut in front and above by a Gigli saw behind. This leaves a tongue above and groove below with the tibia slanted slightly on the pins so that lengthening causes increased forceful apposition of the fragments. The fibula is easily reached intramuscularly through the lateral tibial periosteum and is divided by an osteotome. Whether single or double osteotomy is done seems to make no difference in the lengthening result, and the level of the osteotomy is unimportant. Through the same incision division of the leg fasciae can be done, but it seems unnecessary.

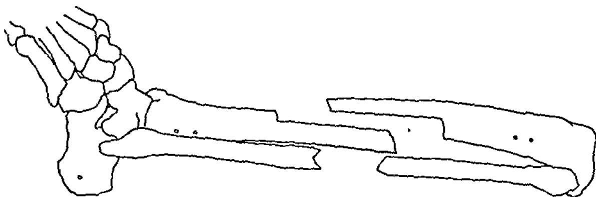


Fig. 769.—Type of osteotomy for leg lengthening. Note site of drill holes for pins

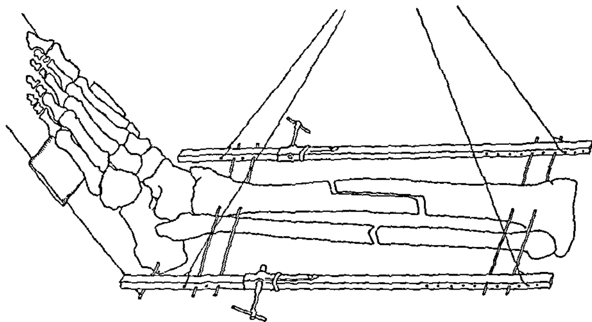


Fig 770—Leg lengthening. Diagrammatic sketch to illustrate apparatus and pins in situ

The side arms of the apparatus can now be placed on the four tibial pins and extended to tautness by the keys (Fig 770). By sliding the lower tibial fragment, lateral displacement can be overcome. If slight lateral angulation is present, further extension of one side arm will overcome it. Anteroposterior displacement is impossible and the fragments will be held very firmly in apposition due to the offset third pin described When perfect alignment has been secured, one can proceed with the closure.

Wound closure should be with interrupted silk, Stewart, or submarine suture and should include merely the skin and half of the fatty subcutaneous tissue. Not

only is it unnecessary to close the periosteal layer, but it will be found impossible to do so. No deep sutures should be used. The pin dressings have already been applied.

The patient is returned to bed and the apparatus is suspended from an overhead frame. Fixed suspension makes the patients more comfortable and the apparatus more stable, all support being through wires permanently fastened to the overhead frame at a definite level without pulleys or counterweights. A sling of muslin fastened to the side arm may be placed under the calf to give a sensation of support and to relieve tension on the suture line. This support should not be too great or it will cause anterior bowing.

Removal of sutures should be done on the seventh day, great care being taken to remove the dressing only over the sutured area of the tibia and tendo achillis without disturbing the dressings covering the emergence of the pins from the leg.

Lengthening should not be begun until two or three days after removal of the sutures when all dressings are off and the actual incisions and the whole leg and foot except the pin holes are open to inspection. If any complication such as hematoma or infection develops during the course of lengthening, no further attempt to secure extension should be made until the complication is overcome. In the usual case, incision will be healed by seven days, the suture holes by the tenth day, and lengthening can safely proceed thereafter at the rate of 0 2 cm. every other day or slightly faster. In children, union will be occurring by the time lengthening is secured, but in adolescents or adults no fear of union interfering with lengthening need arise. In fact, it is delayed in adolescents and may fail to occur without additional bone graft in adults. Plenty of time is allowed, therefore, in these latter cases for overcoming complications and still securing lengthening.

When the desired or maximum amount of lengthening has been secured, the apparatus and limb are removed from suspension. The os calcis pin is removed as usual. A plaster cast is applied inside the side arms, firmly incorporating the tibial pins and their dressings in the plaster. When the cast has hardened, the pins are cut between the cast and side arms with rivet shears and the pin ends are covered with plaster. When wires have been used, clips on the wire ends are included in the cast to prevent the wires from bowing. The plaster boot should extend up the thigh and the cast can be cut and wedged to obtain perfect alignment. The patient can now walk on crutches.

Osteoplasty of the upper defect is generally required if the patient is over twelve years of age and is always required in adults. Graft of the lower defect has not proved necessary, as a large mass of shaft is left there at the time of operation. When the lengthening is complete, roentgenograms will give definite knowledge as to whether bone graft to fill the upper defect in the tibia behind the tongue is necessary. There are several reasons for having the tongue cut above, but the most important is that it places the defect which is largest toward the part of the tibia where osteogenesis is best. If osteogenesis has failed to progress by the time lengthening is complete, there is no reason for delay in grafting this upper defect. It can be done within a week of the application of the supporting cast through a window in the cast, taking bone from the other tibia. Strips of bone

are inserted in the defect abutting the lengthened fragment ends, thus preventing telescoping and loss of length. Following the grafting, the cast is closed again and remains in place until solid union has occurred.

### Femoral Shortening

This is the procedure of choice in equalizing discrepancies in leg lengths in adults. Such is the case because the hazards are of so much less magnitude than are those of leg lengthening, even though one is faced with the disadvantage of operating upon the normal extremity. Shortening the femur is preferable to shortening the tibia. The latter is indicated when the shortening to be compensated for is below the knee. In children femoral shortening should be deferred until the end of the growth period.

Through an anterolateral approach the femoral shaft is exposed by subperiosteal dissection. This should expose the middle third of the shaft, where an oblique osteotomy is performed so that there is proper fitting of the overriding fragments. The osteotomy may be done by making multiple drill holes obliquely across the shaft and connecting them with chisel cuts. The desired shortening is obtained by overlapping the fragments. The position is maintained by three or four metal screws that cross all four cortices (Fig. 771). A double plaster spica cast is applied, extending to the toes of the operated side and to the knee of the opposite side. The cast is worn for about eight weeks Weight-bearing is allowed when consolidation is shown by x-ray examination.

White urges the use of the simple transverse or oblique osteotomy in the middle third of the femur rather than the fancy step-cutting, for the latter is a technically difficult procedure, is time consuming, devitalizes the bone by extensive periosteal stripping, and weakens the fixation

There are several other methods of femoral shortening. One is to do an oblique resection of femoral shaft of the desired length by means of multiple drill holes and the use of a Küntscher intramedullary pin to maintain the apposition. Blount introduced the subtrochanteric femoral shortening operation, using the single-angled blade plate for internal fixation (Fig. 772). The upper femoral shaft and trochanteric region are exposed through a lateral incision. The blade is driven into the neck and the desired length of bone shortening is resected just distal to the trochanter. The ends are approximated and held by three or four screws inserted through both cortices of the femur, and no external fixation is used Crutches may be used at the end of three weeks and weight-bearing may be started when union is complete

Tucker has used the following procedure with good results:

A longitudinal incision of about 15 cm. is made over the anterolateral aspect of the mid-thigh through the skin, subcutaneous fat and fascia down to the muscle sheath. The septum between the vastus lateralis and rectus femoris is identified and an incision is made through the muscle septum. As much of this as possible is done by blunt dissection The rectus and lateralis muscles are retracted, and the vastus intermedius is then identified on the anterior surface of the femur The dissection is continued down to the mid-shaft of the femur. The periosteum is then dissected away from the femur, completely around it, and for the full length of the incision, that is, 15 cm A line is then made with an osteotome on the anterior surface of the femur for a distance of 5 cm to mark the anterior surface, which

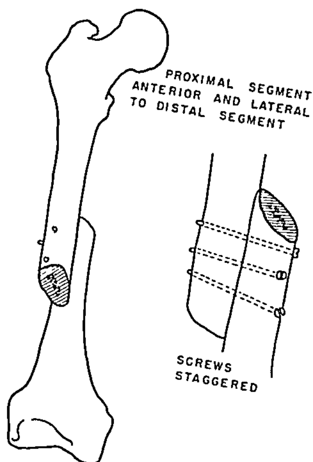



Fig. 771 —White's method of shortening the lower extremity. Following an oblique femoral osteotomy, the overriding fragments are held with three long metal screws.

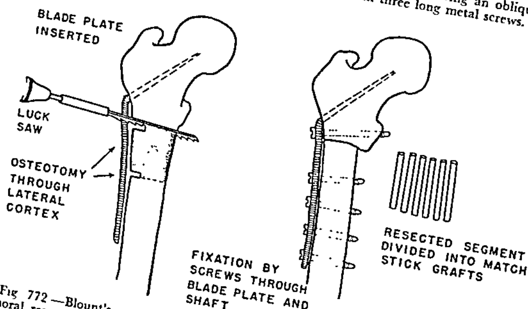



Fig 772 —Blount's method of femoral shortening Insertion of Blount blade plate prior to femoral resection. Fixation by means of screws through the plate and shaft. The match-stick grafts are used to bridge the osteotomy. (From Blount, W : J. Bone & Joint Surg. 25 319, 1943 )

are inserted in the defect abutting the lengthened fragment ends, thus preventing telescoping and loss of length. Following the grafting, the cast is closed again and remains in place until solid union has occurred.

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There are several other methods of femoral shortening. One is to do an oblique resection of femoral shaft of the desired length by means of multiple drill holes and the use of a Küntscher intramedullary pin to maintain the apposition. Blount introduced the subtrochanteric femoral shortening operation, using the single-angled blade plate for internal fixation (Fig. 772). The upper femoral shaft and trochanteric region are exposed through a lateral incision. The blade is driven into the neck and the desired length of bone shortening is resected just distal to the trochanter. The ends are approximated and held by three or four screws inserted through both cortices of the femur, and no external fixation is used. Crutches may be used at the end of three weeks and weight-bearing may be started when union is complete.

Tucker has used the following procedure with good results:

A longitudinal incision of about 15 cm. is made over the anterolateral aspect of the mid-thigh through the skin, subcutaneous fat and fascia down to the muscle sheath. The septum between the vastus lateralis and rectus femoris is identified and an incision is made through the muscle septum. As much of this as possible is done by blunt dissection The rectus and lateralis muscles are retracted, and the vastus intermedius is then identified on the anterior surface of the femur. The dissection is continued down to the mid-shaft of the femur. The periosteum is then dissected away from the femur, completely around it, and for the full length of the incision, that is, 15 cm. A line is then made with an osteotome on the anterior surface of the femur for a distance of 5 cm to mark the anterior surface, which

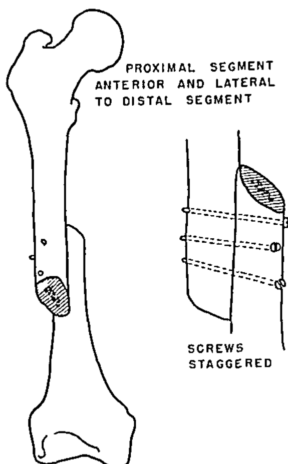



Fig. 771.—White's method of shortening the lower extremity. Following an oblique femoral osteotomy, the overriding fragments are held with three long metal screws.

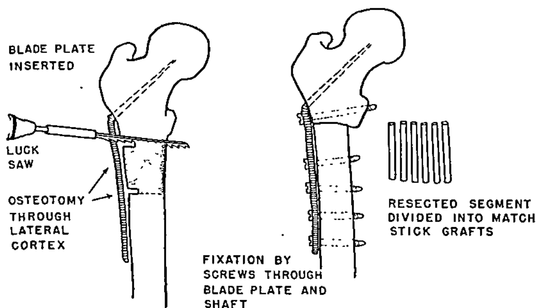



Fig 772.—Blount's method of femoral shortening. Insertion of Blount blade plate prior to femoral resection Fixation by means of screws through the plate and shaft. The match-stick grafts are used to bridge the osteotomy. (From Blount, W.: J. Bone & Joint Surg. 25· 319, 1943 )

*serves as identification when the bone is joined together in the last step of the operative procedure.* With a Gigli saw the shaft of the bone is cut in two (Fig 773). The lower end of the upper fragment is then delivered through the wound with bone forceps. With a coping saw the lower end is cut halfway through, approximately 2.5 cm. from the end anteriorly to posteriorly, and the anterior half of this *section is chiseled away,* leaving a tongue 2.5 cm. long on the posterior aspect of the lower end of the upper fragment. A drill hole is made in this tongue and a double piece of No. 1 chromic catgut is threaded through this hole from below upward. The ends of the catgut are clamped and the upper fragment is then

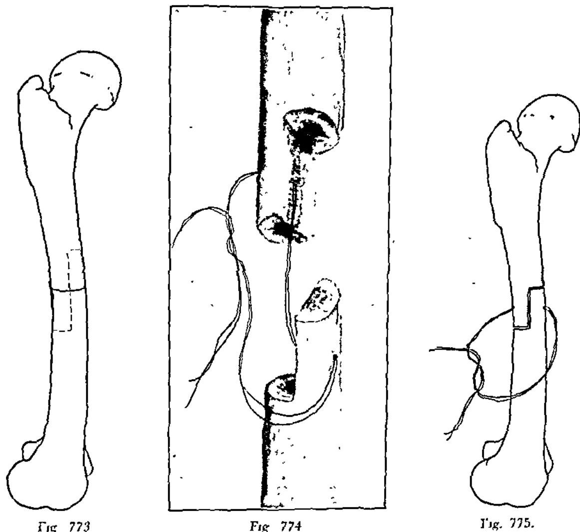


Fig 773 Fig 774 Fig. 775.

Fig. 773.—Operation to shorten the femur Incisions in the bone.

Fig 774.—Operation to shorten the femur The femur has been divided, the two fragments properly shaped, and a *double suture of chromic catgut passed through a drill hole in* each fragment.

Fig. 775—Operation to shorten the femur The shortened fragments have been coaptated and the suture is being tied to hold them in place.

returned into the wound. The upper end of the lower fragment is now delivered *through the wound.* A tonguelike shelf 2.5 cm long is made on this fragment *from the posterior surface* in like manner as described above A drill hole is placed in this tongue corresponding to the place of the hole in the upper *fragment.* The *catgut which was put in the hole in the* upper fragment is threaded through this hole and the fragment is replaced in the wound (Fig. 774). The fragments are

now fitted together, the shelf of the lower fragment fitting on top of the shelf of the upper fragment, the medullary canal of one fragment and the cortex of the other fitting into one another much like tongue and groove (Fig. 775). The catgut is drawn taut and tied. The posterior shelf of the upper fragment serves to prevent posterior displacement of the lower fragment and the tongue and groove fitting of the cortex and medullary canal acts to prevent lateral displacement. The anterior surface markings are now matched together to assure that abnormal rotation has not taken place. The fascia and skin are closed throughout with No. 1 catgut. A plaster spica is applied including both legs and holding the bone fragments in place.

## Leg Shortening by Epiphyseal Arrest

In 1932, Phemister introduced a new principle in correction of excessive length and angular deformity of extremities when he reported the operative arrest of the longitudinal growth of bone. Haas, in 1945, used a wire loop to retard bone growth.



Fig 776—Staples in place for arrest of growth at the distal femoral epiphyses.

He proposed that this loop of wire be removed when the desired change had taken place. In December, 1945, Blount reported a method of epiphyseal stapling. He used staples, similar to those employed by Burns in arthrodesis, osteotomies, and fractures, for retardation of epiphyseal growth. The cessation of growth was complete. The epiphyses grew again after removal of the staples. This method permits earlier correction of limb inequality. It is an operation of minimum risk. However, it is not to be used indiscriminately. It is suitable only for cases with a growth expectancy of several years. White has shown that 1 cm shortening per

year may be anticipated by arresting the distal femoral epiphysis. From 0 5 to 1.0 cm. shortening per year follows arrest of the upper tibial epiphysis. Green and Anderson showed that the yearly growth of the distal femoral epiphysis was 1.3 cm and 0.9 cm. in the proximal tibial epiphysis. From their charts the age for doing the epiphyseal arrest may be determined.

Blount exposes the epiphyseal plates through lateral and medial incisions centered over the epiphysis. Above the knee the obliquity runs from the anterior to the posterior, and the opposite direction is used for the incision below the knee. (Fig. 776.) Two incisions are used to expose the femoral and tibial epiphyses. By splitting the deep fascial layers in the direction of their fibers the periosteum is exposed.

The staples may be inserted without exposing the epiphyseal plate. Some prefer to expose the plate by incising the periosteum and overlying cartilage. The position of the staples must be checked by x-rays if the plate is not exposed. The normal undulation of the epiphysis must be allowed for on insertion of the staples The staple at the distal femoral epiphysis must be more distally placed on the femur. At the proximal end of the tibia the staple must be placed more proximal due to the undulation in the epiphysis. Three staples are used in the femoral epiphysis, and their position must be accurate as determined by the check roentgenogram. The proximal fibular epiphysis is not stapled but is curetted when the proximal tibial epiphysis is arrested. After determining that the position of the staple is correct, the wounds are closed and a cylinder cast is applied for three weeks The patient is permitted to walk as early as he desires There must be careful follow-up studies on the patients who have had stapling.

## MALUNION OF THE RADIUS

Malunion of Colles' fracture is unsightly and is disabling. Malunion of the radius occurs more often than it does in any other fracture. Surgery is indicated in order to improve the wrist function when impaired by the malunion. There is also improvement in the appearance of the wrist, and the cosmetic result is not to be overlooked.

Bennett, Inclan, Durhan, Ghormley, and others, describe an osteotomy of the radius to correct the malunion. The corrected position was maintained by a wedge-shaped graft. Bennett obtained the graft for this wedge from the tibia.

Campbell's operation restores the normal angle of the articular surface, corrects the radial shortening and the undue prominence of the ulna and the broadening of the wrist, thus reproducing normal bony and external contour.

A lateral incision about 5 cm. in length is made over the lower end of the radius The incision is carried through the skin and fascia between the brachioradialis and the abductor pollicis longus and extensor pollicis brevis muscles to the line of the fracture and the fracture is exposed An osteotomy is made transversely through the fracture site of the radius about 2 cm. proximal to the articular surface, after which correction of the posterior angulation of the lower fragment can be made by acute flexion of the wrist joint so that the lower fragment is angulated slightly downward and forward In this position a hemostat can be inserted between the fragments and opened with moderate force, thus separating the fracture surfaces and demonstrating the amount of increase that can be obtained in the length of this bone. A skin clip is now placed so as to close this wound temporarily.

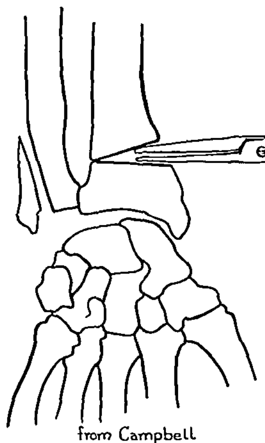
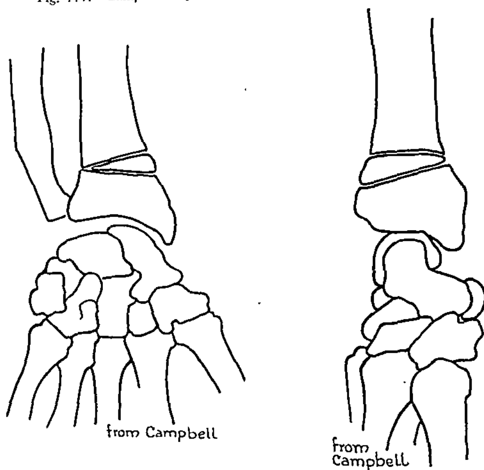



Fig. 777.—Campbell's operation for malunited Colles' fracture.




Figs 778 and 779.—Campbell's operation. The graft from the lower end of the ulna has been placed between the radial fragments; anteroposterior and lateral views.

An incision is then made for about 5 cm. over the medial aspect of the lower extremity of the ulna through the periosteum, which is stripped off of the inner half from above downward, exposing the articular surface and the styloid process With a small osteotome the inner half or third of the head and inner portion of the shaft is severed from below upward, thus securing a free graft of bone about 2.5 cm. in length and about 1 cm. in thickness at one extremity and tapered at the other (Fig. 777). This graft is placed in a covered sterile pan or sterile towel.

The free graft of bone is now trimmed with bone forceps to make a pyramidal wedge with a base on the dorsal as well as the lateral aspect and is inserted into the space between the fragments. The dorsal wedge maintains the normal angle; the lateral wedge prevents recurrence of radial shortening (Figs. 778 and 779). Care must be taken that there is slight overreduction of the lower fragment; that is, slight anterior angulation. Both wounds are then closed in a routine manner and dressed with small gauze pads. On inspection the external contour should be approximately normal except that the head of the ulna may not be prominent. The lateral dimension or width of the wrist joint should be normal; and on palpation the lower extremity of the styloid process of the radius should be distal to that of the lower extremity of the ulna.

A sterile flannel bandage is placed from the metacarpophalangeal joints below to just above the elbow, and the sugar tong cast or molded plaster anterior and posterior splints are applied. While this is consolidating, the forearm is held in mid-position, the wrist in slight flexion, with pressure over the dorsum of the wrist so as to make the posterior capsule of the wrist joint tense, thus maintaining the lower fragment of the radius.

A roentgenogram is then made which should demonstrate practically normal anatomic alignment; the lateral view will show that the normal plane of the lower articular surface of the radius has been restored, while the anteroposterior film will show that the styloid process of the radius is about 1.25 cm lower than the lower extremity of the ulna, the styloid process of the ulna having been removed. Roentgenograms should be made through the plaster splint at the end of one week and two weeks, in a routine manner, to determine the position and thus adjust any slight recurrence of the deformity. After one month the plaster splint is removed and a small anterior metal splint is applied with straps and buckles to allow frequent removal for active and passive exercises and for physical therapy

## OSTEOTOMY

*Osteotomy is most useful for correction of deformity* at the knee or at the hip but may also be employed at other sites. Many different types of osteotomy have been described, but at present practically all have been discarded except the linear and the wedge osteotomies. The linear osteotomy is simple, proper alignment is usually obtained easily, and there is not as much danger of losing position as after a wedge osteotomy.

An incision is made over the bone at the point selected for correction, the osteotome is carried down to the bone in its long axis and turned at right angles to the long axis when the bone is reached With a hammer it is driven transversely almost through the bone with several light blows, taking care to loosen it after each blow in order to prevent the osteotome from being caught and held in the bone.

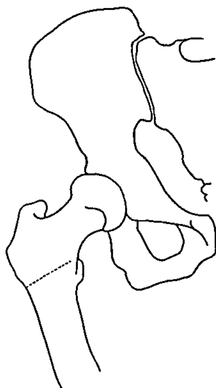


Fig 780.—Direction of Gant's osteotomy for correction of adduction deformity of hip.

Fig 781.—Osteotomes of varying widths.

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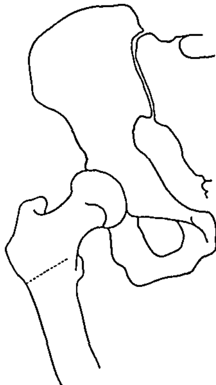


Fig. 780.—Direction of Gant's osteotomy for correction of adduction deformity of hip.

Fig. 781.—Osteotomes of varying widths.

The bone is divided only far enough to allow it to be broken manually so that the periosteum on the side opposite the incision may prevent the fragments from slipping by each other. The incision is closed, proper alignment to correct the deformity is obtained and is maintained by a plaster cast which embraces at least the joint above and that below the osteotomy.

To correct knock-knee, the osteotomy is usually done just proximal to the femoral condyles, the incision being made just above the adductor tubercle. Occasionally it is better to do it through the upper end of the tibia. For bowlegs it is done through the apex of the bowing. Here a wedge osteotomy is sometimes necessary, but with it union is often delayed. In some cases of clubfeet or of bowlegs a rotation deformity is present in the tibia. Here a procedure suggested by Hess is valuable. He exposes the area selected and makes several parallel vertical osteotomies about 0.625 to 1.25 cm. apart for two-thirds the circumference of the shaft of the bone. This has the effect of giving a somewhat crushing fracture with the two main fragments held by a strong periosteal bridge. After this both the rotation and the bowing may be corrected manually without fear of losing contact between the fragments.

If there is flexion deformity at the knee as well as knock-knee, a wedge athrodesis, to be described later, is often needed. This, of course, eliminates motion in the knee joint.

For correction of fixed adduction or adduction-flexion deformity at the hip, Gant's osteotomy is done. This is a subtrochanteric osteotomy with the line of division from outward and downward, inward and slightly upward (Fig. 780). It is carried almost through the femur, and then the remainder of the bone is broken manually and the proper alignment is obtained. If a Gant operation is done to correct deformity following tuberculosis of the hip, the surgeon must be careful to ascertain that the disease is arrested; otherwise it may become acute after the operation This operation has been found to be extremely useful and of very little danger.

Osteotomy is of value also in correcting deformity in many cases of malunited fractures. In the forearm and in the leg a simple linear osteotomy will often greatly improve both appearance and function after malunion The important thing in all osteotomies is not so much the type of osteotomy used as the point selected for the section and the surgeon's ability to calculate the plane of the cut and to line up with his eye, so to speak, the various anatomical landmarks In performing an osteotomy, it is well to support the limb at the site of the operation on a sandbag. It is advantageous to have several osteotomes of varying width and thickness instead of trusting to the same instrument for all osteotomies (Fig. 781).

## REMOVAL OF THE COCCYX

Excision of the coccyx may be indicated in cases where one is certain that functional disturbances or nervous instability is not the background of the complaint of pain in the coccyx, for the coccyx may be removed and still the complaint recurs. When pain is produced by pressure on sitting because of a rigid coccyx and when pain arises from traumatic arthritis when the sacrum and coccyx are prominent, removal of the coccyx should be considered. In most cases, however, conservative measures will make removal of the coccyx unnecessary. The incision is a midline vertical one over the sacrococcygeal joint. This joint is opened by

excision of the cartilage between the coccyx and sacrum. The posterior surface of the coccyx is exposed by sharp dissection. The upper end of the bone is caught in a towel clip and elevated so as to facilitate dissection close to the bone. It is important to dissect close to the bone for the rectum lies near the coccyx. The coccyx is removed in one piece. Key advocates leveling off the prominent lower end of the sacrum, to prevent pressure irritation. The wound is closed by using chromic catgut to approximate the aponeurosis dissected from the coccyx. The subcutaneous tissue is closed with plain catgut, and the skin is closed with a silk suture.

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# CHAPTER 65

# OPERATIONS ON TENDONS

M. Josiah Hoover, Jr.

## REPAIR OF OLD INJURIES

Successful tendon surgery requires meticulous attention to detail both before and after operation. There must be strict adherence to the principles as discussed in the treatment of fractures. The outcome of tendon surgery depends upon gentleness in handling tissue, superaseptic technic, and careful control of bleeding. Any repair of tendons is accompanied by adhesion formation. To keep this at a minimum one must scrupulously adhere to the three principles mentioned above.

To Bunnell must go the credit for making many of the advances in the methods of tendon repair and for establishing many of the principles of modern tendon surgery. It has been through his genius that operations have been devised and special instruments invented for this special field. These instruments are necessary for successful tendon repair. He has shown that tendon grafting can be on the same successful basis as the bone graft. Leo Mayer and Biesalski first described the importance of the paratenon and its part played in the gliding mechanism of tendons. Mason, Allen, and Koch have contributed much to our knowledge of primary care of the acute injury, so that the initial treatment is often the final treatment.

Proper functioning of the hand is essential in all walks of life, and as more than one-third of the industrial accidents are of the hand, tendon repair of the hand is important and frequently difficult Tendon repair is often required when gross infection has occurred. This infection may lead to scar tissue formation which binds together the moving structures, and some tendons may have been destroyed by the infection Tendon repair is real reconstructive surgery, and building up parts that will move and function properly requires meticulous and accurate technic.

One of the first procedures is to excise all old scar tissue. Extreme gentleness and delicacy may prevent further trauma, and reduce to a minimum recurrence of fibrosis. A blood pressure band should be used as a tourniquet to produce a bloodless field, thus reducing the trauma of sponging and permitting more accurate dissection The tourniquet of this type may be kept on safely for one hour, and during this time all of the dissection and much of the repair work should be completed. The tourniquet may be released and after five or ten minutes may be reapplied. By working rapidly during the limited tourniquet time, reapplication is rarely necessary. The tourniquet is best applied after the blood is forced out of the extremity with an elastic bandage The blood pressure cuff is reinforced with a gauze bandage, and the pressure in the bag is raised to 300 mm. Hg

Since a stiff joint will defeat the purpose of tendon repair, they should be mobilized before the tendons are repaired. Any bone repair needed should be done before operating upon the tendon, because immobilization is necessary for bone repair, whereas the latter requires mobilization. Nerve repair should also precede repair of the tendons.

Local anesthesia, especially with Adrenalin, should be avoided in this type of surgery, as tissue vitality is lowered by the local agent. For extensive work general anesthesia is indicated, although block anesthesia may be used in short procedures.

In repairing an old injury of a flexor tendon in the finger one should have in mind the pathology of tendons after injury and infection. The difference in the reaction of the tendon injured within the sheath and within the paratenon should be understood. The tendon sheath is an adaptation to enable a tendon to turn a corner. The paratenon is present where the tendon pulls straight. The tendon makes an effort to reach out when it is severed in the paratenon and by this method tendons grow together, reestablishing their continuity. When the tendon sheath surrounds the severed tendon, the ends make no effort to proliferate and become rounded over. If the tendon end is free, it will firmly attach itself.

After freeing the tendon and excising the cicatrix, it is usually impossible to draw the parted ends together for suture, and repair may require a free tendon graft. The muscle contracts the distance of the amplitude of motion of the tendon and this contracture becomes fixed after two months. The ends of the severed tendon are damaged and length is lost from this damage. A rough adherent tendon will become adherent again, so a free tendon graft should be used to replace this rough adherent segment. Tendons of moderate size may be satisfactorily grafted, and old injuries of the flexor tendons of the fingers are the frequent site for tendon grafting.

In repairing the old injuries of the flexor tendons of the fingers the sublimis tendon is sacrificed and the profundus tendon is reconstructed. There is not sufficient room for both tendons. If suturing is done at the insertion of the tendon, in the palm, or forearm, adhesions do less harm than when the suture line falls in the narrow firm sheath of a finger. The tendon graft plus its paratenon as a complete gliding assembly should be used in the graft. This graft may be obtained from the sublimis tendon of the same finger, the palmaris longus, or the long extensors of the toes on the dorsum of the foot. The latter two can be removed with their paratenon. A free graft paratenon may be placed about the tendon at the time of grafting.

The method of tendon suture and tendon graft described by Bunnell is shown in Figs. 782, 783, 784, 785, 786, 787, and 788 He emphasizes the need of reducing suture material or foreign body to a minimum. Two strong strands are used in preference to many strands. The purpose of the suture is to maintain the ends together until physiologic union has occurred at the end of three weeks. The stitch should be placed in the tendon by braiding so that strength is obtained without strangling the tendon tissue. The surface stitch forms adhesions and therefore a cone stitch is preferably used.

In these illustrations each tendon end is spliced The opposing strands are tied together, which leaves a knot between the two ends on either side. Bunnell's later technic is to place the silk in one tendon end, to draw out the slack, and to continue splicing it up the other end. The slack is drawn out by sliding the tendon down each taut strand one at a time. A single knot is tied some distance from the

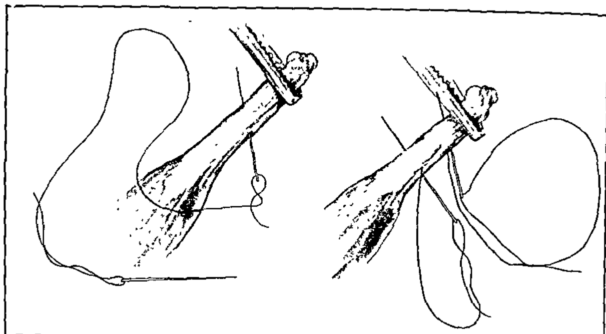


Fig 782. Fig. 783.

Fig 782.—Bunnell's method of tendon suture. Beginning the suture.

Fig 783.—Bunnell's method of tendon suture The needle at other end of suture is passed through the tendon.

Fig 784

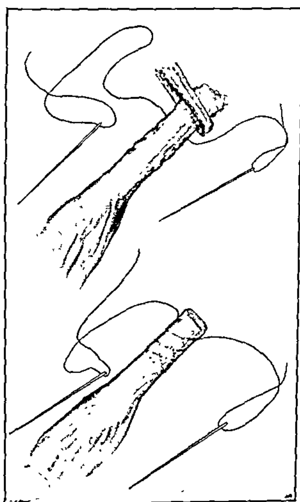


Fig. 785

Fig 784 —Bunnell's method of tendon suture. Suture completed except for piercing end of tendon

Fig 785.—Bunnell's method of tendon suture Showing how suture is woven into the tendon.

cut ends and thus at the point of least strain. This stitch is used for suturing the tendon graft to the tendon end. If the graft is short, it is threaded over two strands of silk (Figs. 788 and 789).

Bunnell has introduced and perfected the use of removable stainless steel wires. The wire used is of small caliber and it is removed. Both of these facts lessen tissue reaction at the point of repair. The wire suture is spliced through the proximal end and then passed on down through the other tendon and out through the skin to be fastened over a button or to the fingernail A fine arterial silk suture may be used to approximate the two ends whenever needed (Fig. 790).

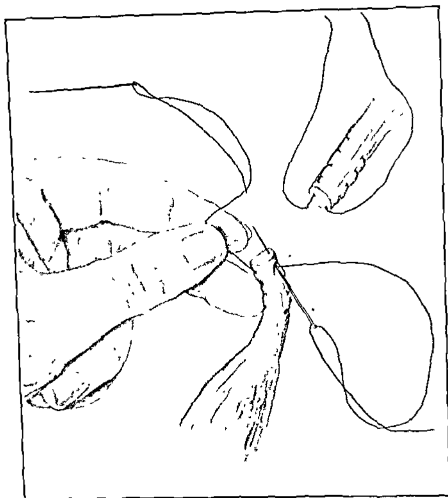


Fig 786 —Bunnell's method of tendon suture. Completion of the sutures

The pull-out wire is placed under the proximal loop of the stitch. The ends of this wire are threaded on a needle and brought out through the skin proximal to the tendon juncture and left. After three weeks the wire is clipped at the button and extracted by means of the pull-out wire. The end-to-end suture may be done at a distance, the suture being in a remote site from the juncture. The wire used for flexor tendons of the hand is No. 34 (Fig. 791).

The flexor tendons of the fingers are kept in place by three pulleys, one at the metacarpal head and one each opposite the middle of the proximal and middle phalanges. If these are destroyed, they must be replaced by making a loop of free tendon graft and suturing its ends together so that it encircles both the bone and the flexor tendon. Fig. 792 illustrates one of these pulleys as well as the tendon reconstructed from a free graft of tendon plus its paratenon.

The location of incisions in the hand is very important. "An incision should be remote from tendon sutures or grafts, should not cross a flexion crease at right angles, should parallel the creases and be L-shaped in the palm, should never cut the nerves of the hand or fingers and especially the thenar motor branch In the forearm and wrist short transverse ones will often suffice . . . In the fingers mid-lateral incisions are best and they should, unless long, be opposite the joints where there are no pulleys." (Bunnell.)

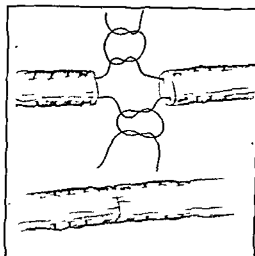


Fig. 787.—Bunnell's method of tendon suture. Tying the sutures so as to coaptate the ends of the tendons

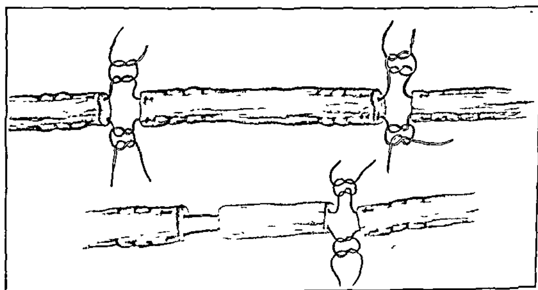


Fig. 788—Bunnell's method of tendon suture. Upper drawing shows the suture used when a long tendon graft is used The lower drawing shows a simpler method possible when the graft is short

For removing a tendon from a mass of adhesions Bunnell's stripper made from a cork borer is used (Fig. 793) With its sharp edge and a twirling motion it planes the tendon from the adhesions. To place a tendon through a tunnel in the finger, his flexible probe is employed. It expands flatly at its center, so as to widen the tunnel, and terminates posteriorly in a funnel to receive the end of the tendon and draw it through

The tension for uniting a tendon, according to Leo Mayer, is fixed by the following rule: When the origin and insertion of the muscle are approximated as near together as possible, the tension of the tendon should be zero.

After the operation, postoperative splints are used on the fingers only for extensor tendons, to guard them from the strong pull of the flexors. For flexor tendons the wrist is kept in flexion for a month by an angulated flat dorsal splint, and

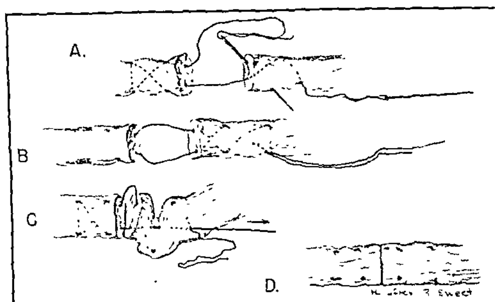



Fig. 789—Bunnell's method of suturing a tendon with silk The knot is placed so as to sink into the tendon at the point of least strain. (From Bunnell, S.· *Surgery of the Hand*, J B. Lippincott Co, 1944.)

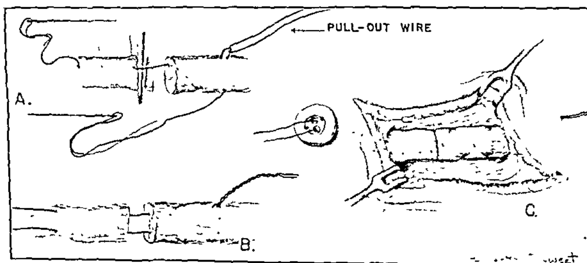



Fig 790—Bunnell's technic of tendon suture with stainless steel wire. *A*, Making the stitch *B*, The completed stitch. *C*, The tendon ends are approximated. (From Bunnell, S.: Surgery of the Hand, J. B Lippincott Co., 1944.)

exercise is started the day after the splint is removed. In order to keep the tendon in the finger mobilized, the finger must be voluntarily flexed while the proximal two segments are passively held extended, else all of the movement will take place at the proximal joints. Final results are often not obtained for a year or more.

Before the operation is undertaken, it is extremely important that the utmost be done for the hand by physiotherapy. Unless the finger joints are perfectly flexible, the reconstruction of a tendon cannot be expected to be helpful. Every available means of freeing adhesions, of mobilizing joints, and of improving the circulation must be utilized before tendon surgery is begun.

With these general principles and special features of tendon repair in mind, let us describe an operation for the repair of a flexor tendon of the finger

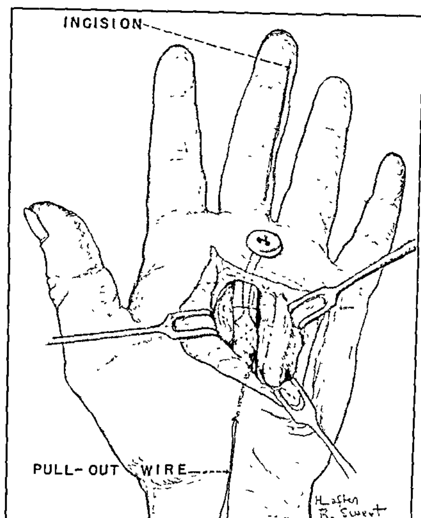



Fig 791 —Bunnell's method of using a removable stainless steel wire for suturing a tendon in the palm (From Bunnell, S : Surgery of the Hand, J B Lippincott Co, 1944 )

As a tourniquet the blood pressure band is pumped up to 300 mm. An L-shaped incision is made in the palm near the proximal end of the divided flexor tendon, the transverse bar of the L following a palmar crease. All scar tissue is removed by sharp dissection The remaining distal portion of the flexor tendons is stripped out of the finger with Bunnell's stripper, and a lateral incision is made opposite the distal joint of the finger to facilitate freeing the profundus from its insertion and also to expose the point of insertion for the graft. In some cases a cross-bar incision to this is made across the flexor surface of the distal phalanx. If the tissues in the finger are fairly soft and free of cicatrix, then the proximal part of the sublimis tendon with its delicate paratenon may be used as the graft. A short transverse incision is made on the flexor surface of forearm, the proper tendon identified,

and drawn up into the forearm and there severed. It is well then to attach the proximal end of the sublimis to the corresponding profundus. If the sublimis cannot be used as a graft, a toe extensor tendon may be obtained with its paratenon. If there is cicatrix in the finger, it is well to wrap the graft with a sleeve of paratenon fat obtained from over the triceps tendon. The graft is then sutured to the proximal end of profundus tendon by the method of suturing as shown in Figs 787 and 792. This gives a strong connection with a minimum of exposed silk. The free end of the graft, in which sutures have been inserted, is then placed in the funnel end of

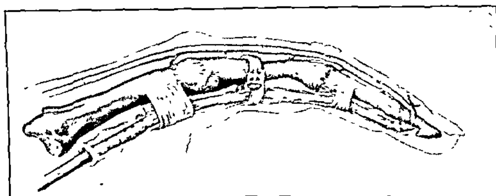


Fig 792 —Bunnell's method of replacing destroyed flexor profundus tendon in the finger. A tendon graft, with paratenon or a paratenon fat "sleeve" about it, has been sutured proximally to the remaining tendon and distally to the terminal phalanx. A pulley has been remade from free tendon graft for the middle phalanx.

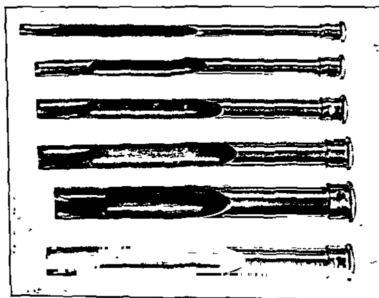


Fig. 793 —Bunnell's tendon strippers made from cork borers

Bunnell's flexible probe with the sutures hooked over the peg in it, and is drawn through the tunnel in the finger to the distal phalanx. The distal phalanx is first scraped for bony contact, then the two sutures in the distal end of the graft are passed through a drill hole in the phalanx and are secured through the insertion of the extensor tendon If the pulleys have been destroyed, new ones are made of free tendon grafts which encircle the grafted tendon and the bone. The incisions are closed with interrupted fine nonabsorbable sutures and the wrist joint is splinted in flexion, leaving the fingers free.

## TENOTOMIES AND TENDON LENGTHENING

Subcutaneous tenotomy was probably the first orthopedic operation ever performed. Asepsis, by removing the fear of an open incision, has eliminated most subcutaneous tenotomies, but they survive in certain cases of clubfoot, congenital or paralytic. Certainly a subcutaneous tenotomy of the sternomastoid muscle for torticollis should never be done, and it is questionable whether all subcutaneous tenotomies were not better replaced by tendon lengthening. In a subcutaneous tenotomy, there is always danger of a wider separation of the cut ends of the tendon than is desirable, and in congenital equinovarus this sometimes results in a weak gastrocnemius and a flat calf with a bulge too near the knee. However, subcutaneous tenotomies of the Achilles tendon and of the plantar fascia are still fairly generally used for the equinus and the cavus deformities, respectively, resulting from congenital clubfeet and from anterior poliomyelitis.

For tenotomy, the tenotome, a special long-handled, small bladed knife is used (Fig. 794). There should be two of these, one with a sharp end, the other with a blunt end. For dividing the tendo achillis, the first tenotome punctures the skin just to the inner border of the tendon and is carried to the edge of the tendon. The blunt-ended tenotome is then inserted through this puncture, carried across the tendon posteriorly, and the tendon, while put on the stretch, is divided by a sawing motion.

The same procedure is carried out in the sole of the foot to divide the plantar fascia. The fascia is often divided at several points through multiple puncture wounds.

Where a tendon is too short, lengthening the surgically exposed tendon is far better than doing the work blindly. Numerous methods of lengthening tendons have been advised, but only three will be described. As the Achilles tendon is the one most frequently lengthened, operation on it will be described.

**Lengthening of Achilles Tendon.**—An incision is made just to the inner side of the tendon, the fascia and connective tissue over the tendon are split, and the tendon is exposed. The plantaris tendon is divided Then the tendon is lengthened as follows:

a. Hibbs' method: In the upper plane the tendon is cut two-thirds of the distance across. It is then split distally from the end of this cut for about one-half the amount it is to be lengthened In the lower plane and beginning on the side opposite to the first incision, it is divided two-thirds of the distance across just distal to the end of the splitting incision From the extremity of this transverse incision the tendon is then split proximally for about one-half of the amount of lengthening required to a point a short distance from the upper transverse incision. When the foot is dorsiflexed, the tendon is drawn out and the piece circumscribed by the transection will unfold itself meander shaped and will lie between the upper and lower incisions (Fig 795).

b. A simpler method, which does not give as much lengthening, is to divide the tendon transversely two-thi [illegible]
allowing the tendon halves [illegible]
796).

c The third method divides the tendon half across at different levels on opposite sides, and connects these incisions by a longitudinal splitting incision The

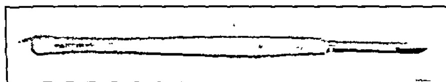


Fig. 794.—Tenotome.

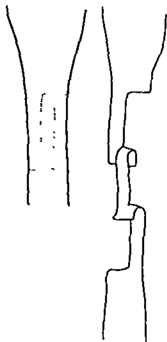


Fig. 795.

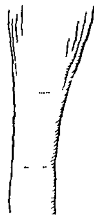


Fig. 796.

Fig 795.—Hibbs' method for lengthening the Achilles tendon.
Fig 796.—Tendon lengthening by cross incisions.

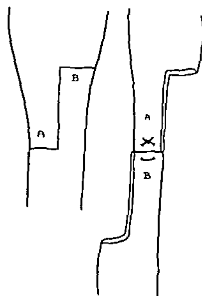



Fig. 797.—Tendon lengthening by incision and mattress suture.

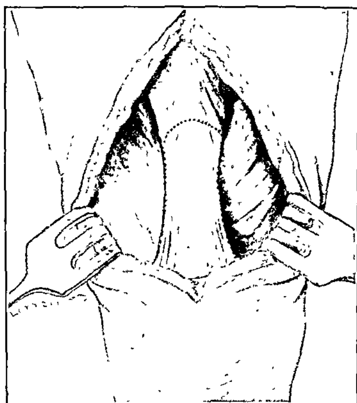


Fig. 798 —Bennett's operation for lengthening the quadriceps tendon Incisions in the tendon

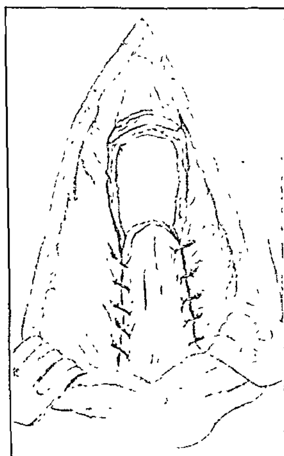


Fig 799.

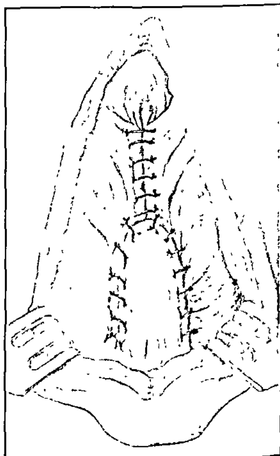


Fig. 800.

Fig 799 —Bennett's operation for lengthening the quadriceps tendon Suture of the tendon flap after flexing the knee.

Fig 800 – Bennett's operation for lengthening the quadriceps tendon. Completion of the reconstruction of the tendon.

tendon is then stretched out and the upper end of the distal portion is sutured to the lower end of the proximal portion by a mattress suture of catgut (Fig. 797).

After any method, the sheathlike connective tissue is carefully sutured over the tendon, the skin is closed, and a plaster cast is applied for six weeks with the foot at a right angle to the leg.

White, in 1943, presented his method of tendo achillis lengthening. In this procedure the surgical significance of the torsion of the tendo achillis is utilized. The tendon is exposed through a posteromedial incision. Its anterior two-thirds is incised near the insertion The foot is held in dorsiflexion and the medial two-thirds of the tendon is sectioned several centimeters proximal to the first incision. The tendon is lengthened by the dorsiflexion of the foot. No sutures are required.

**Bennett's Method for Quadriceps Lengthening.**—Sometimes after fractures, inflammatory conditions, or long immobilization of the knee in extension, in order to obtain flexion it is necessary to lengthen the quadriceps tendon. Bennett makes an incision from the patella upward to the junction of the lower and middle thirds of the thigh. The incision is carried down to the muscle, the vasti are bluntly dissected, and the attachment of the rectus femoris to these muscles and to the capsule of the knee joint is exposed. Longitudinal incisions on each side of the tendinous portion of the rectus femoris muscle are made. These incisions are deepened to include the tendinous section of the vastus intermedius and to separate both muscles from the other vasti At the upper edge the incisions are connected by a transverse incision (Fig 798). The tendon tongue thus made is freed from the underlying tissue until the knee can be flexed With the knee flexed, this tendinous flap is sutured with chromic catgut on each side to the adjacent vastus (Fig 799) and the muscles are brought together above it to close the gap left by its transplacement (Fig. 800). The knee is fixed in flexion by a plaster cast.

*For spastic flatfoot in which the foot is everted by the tense peroneal tendons,* an incision is made over the tendons just proximal to the ankle and a small portion of both the longus and the brevis tendons is resected

## TORTICOLLIS

Torticollis or wryneck is either congenital or acquired. True congenital torticollis is probably extremely rare. The primary cause of torticollis usually described as congenital is generally due to trauma. The most plausible explanation of this trauma is the one given by Chandler and Altenberg. They believe a number of forces may derange the anatomy of the sternocleidomastoid muscle. These forces are the result of intrauterine malposition and trauma during delivery. The acquired torticollis may be due to injury or to disease of the cervical vertebrae or to dense scar developing in deep burns of the neck. Spasmodic wryneck, which usually appears during middle age, is always acquired. Its etiology is somewhat mysterious, and it is now believed to be a lesion of the basal ganglia. The suggestion that it may be due to an inflammatory lesion within the central nervous system has not been consistently borne out at the time of operation or at autopsy.

Middleton seems to have shown that the so-called congenital torticollis is usually the result of interference with the return of the venous blood in the sternocleidomastoid muscle, probably caused by an obstruction of the veins during prolonged

labor, with clotting and subsequent hemorrhagic infarction of the muscle. The clotting is evidenced by the development of the sternomastoid tumor in infancy. The tumor is a hard immobile fusiform swelling which increases in size from two to four weeks. This eventually disappears, being replaced by fibrous tissue. As Middleton states, the torticollis becomes noticeable when the child's neck begins to grow longer rapidly at about the fourth year, the nonelastic fibrous tissue on the affected side causing the noticeable deformity.

The treatment in older children with fixed deformities is operative intervention. Many infants with "tumors" will have no deformity later. Treatment begun at the early stage may arrest the development of the deformity. Manipulation and exercises may be sufficient, the head being turned into a position to stretch the sternocleidomastoid muscle. This should be done daily, and it is helpful to place the infant's crib so that the muscle is stretched when the infant turns to look at the approaching mother. A light on the opposite side of the affection may help, as the infant watches the light as he goes off to sleep, stretching the affected muscle. Surgery for these infants, according to Chandler and Altenberg, should be performed only in those cases where progressive shortening of the muscle and increase in the severity of the associated deformity of the head and face are observed. Their procedure is to make a transverse incision above the clavicle, exposing the tumor by splitting the platysma muscle The muscle is freed from the clavicle by transverse cuts. The tumor is freed from the deeper structures and removed by cutting through the muscle at the junction of the upper and middle third. The head is held in an overcorrected position for two weeks, after which stretching is instituted.

Fixed deformities should be corrected within the first few years of life before the changes are pronounced, and, certainly before the development of secondary changes in the face, skull, and spine. Closed tenotomy is a dangerous and inaccurate procedure. In older children and adults the open operation may be done under local anesthesia, but general anesthesia is essential in younger children. The shortened muscle is rendered prominent by placing the head over a sandbag. An incision 5 cm. in length is made over the lower half of the sternomastoid muscle. The muscle is divided at its insertion into the sternum and clavicle, and the fibrous part is excised. The wound is closed, using a subcuticular stitch, if desired The proximal attachment of the muscle may be released by a transverse incision below the mastoid process. Postoperatively, the head should be held in head traction for two weeks. After this, physical therapy and stretching with overcorrective exercises are begun; they are continued for three to six months with night traction for the same period.

Spasmodic torticollis, usually occurring in adults, is characterized by clonic contractures of the muscles pulling the head by a sudden jerk over to one side and rotating the face to the opposite side. This spasticity may be mild or completely incapacitating The treatment is empirical since the etiology is unknown. Previously, treatment consisted of division of the skin, muscle, or excision of a portion of the muscle. In very early cases where only the muscle is involved this procedure may give relief. However, most of the muscles of the neck are usually involved and more radical surgery is required The major surgical procedure should be undertaken upon the patient's request. One should be certain that the disease is organic and is not a generalized dystonia.




Fig. 801.—Sever's operation for obstetrical paralysis Incision for exposure of the shoulder joint

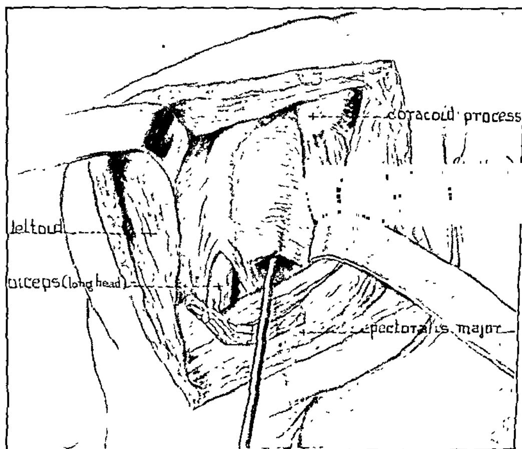



Fig. 802—Sever's operation for obstetrical paralysis. Exposure of the anterior surface of the capsule of the shoulder with sound under subscapularis tendon

all of the nerves will not be divided. However, if complete hemostasis is obtained during each step, the nerves should be exposed relatively easily and should be identified by stimulation with an electrode.

Within the past few years, this operation has been replaced to a considerable extent by the intradural division of the upper three or four spinal nerves and either the intradural or cervical division of the spinal accessory trunk. The latter operation is undoubtedly a simpler procedure and is probably preferable if done by one familiar with the surgery of the central nervous system. The intradural operation is described in the section on neurologic surgery (Chapter 87).

Another condition requiring resection is the shoulder contracture following obstetrical paralysis. Sever does an open tenotomy of the subscapularis tendon for the correction of the adduction and internal rotation deformity of the arm. He states that this procedure is indicated in patients past four or five years of age.

An incision is made from the outer end of the clavicle down the front of the arm to the insertion of the pectoralis major, following a line between this muscle and the deltoid (Fig. 801). The cephalic vein is retracted outward with the deltoid, and the pectoralis is retracted inward, its tendon being incised at the point of insertion, if necessary, for this retraction. The joint capsule is thus exposed in the sulcus between these muscles, with the long head of the biceps lying laterally and the short head and the coracobrachialis in the medial portion of the wound (Fig. 802). When the arm is abducted and outwardly rotated, the transverse fibers of the subscapularis tendon at its insertion into the joint capsule are brought into view. A director is passed under the tendon and the tendon is divided across it, without opening the capsule of the shoulder. As soon as this is done, the arm may be easily rotated outward. The incision is closed in layers and the arm immobilized in abduction and external rotation on a splint or by plaster cast. Sometimes it is necessary to divide also the short head of the biceps and the coracobrachialis. As will be seen later, this incision is useful for other operations on the shoulder.

## TENDON TRANSFERENCE

No longer does tendon transference hold the prominent place in orthopedic surgery that it once did. Experience has shown that physiologic and biologic factors are of as much importance in successful tendon transference as purely mechanical considerations This has considerably limited the field of application, but it has put the remaining operations on a firmer basis

The necessary principles for a successful operation can be briefly stated The muscle used must have a similar or related action to that muscle which it replaces. The entire tendon must be transferred, as using a portion of a tendon is both mechanically and physiologically wrong The strength of the muscle used as a transfer must be as near as possible to that of the one it replaces The transferred tendon must run directly from its point of origin to the new insertion, so that the pull is in a straight line. The work of Biesalski and Mayer has shown the importance of the preservation or of the substitution of a gliding apparatus for the tendon The proper tension of the transfer is important. All deformity must be corrected *before* the transfer is done Often this requires a bony stabilization operation preceding or accompanying the transference, as without this the deformity will recur Finally, the transferred tendon must in most cases be firmly

anchored to bone by a periosteal slot or a hole drilled through the bone, although, in the upper extremity, tendon may be attached to tendon by buttonhole suture. *Before any muscle transference* is performed, an adequate muscle check of the site in question is of greatest importance. This enables the surgeon to know what muscles can be used for transference and the motor power that the said muscle can be expected to furnish. The method of muscle testing set forth by Kendall and Kendall of the Children's Hospital School is best, where such muscle testing is desirable.

In the upper extremity, tendon transference is advised for the paralysis of the extensor apparatus of the wrist and fingers following musculospiral paralysis, infantile paralysis, or spastic paralysis. For the last condition, in our experience, the operation usually fails. In infantile paralysis often there are not enough active flexor muscles present to transfer both as wrist and as finger extensors, and the wrist must be stabilized by arthrodesis. Thus it is in cases of pure musculospiral paralysis that the operation of Sir Robert Jones, or the Billington modification of the Jones technic, is most satisfactory.

The first incision is made over the dorsum of the hand, exposing the tendons of the extensor carpi radialis longus and brevis. One of these tendons is split and the bone underneath is grooved for the insertion of the transfer. A second small incision is then made proximal to the annular ligament and a probe is passed upward from the first to the second incision in the sheath of the extensor carpi radialis to serve as a guide for the tendon transplanted later. A long volar incision is then made, exposing the flexor carpi radialis This incision must be sufficiently long to expose the insertion and to free the muscle high enough to give it a direct pull around the outer border of the radius. This tendon is then brought around the radius subcutaneously to the upper dorsal incision and is transferred by a guide suture in the probe into the sheath of the extensor carpi tendon. From here *it is sutured to the extensors of the thumb and the index finger. The pronator radii* teres is then freed in the volar incision and sutured to the two extensor carpi radialis tendons. Finally, the flexor carpi ulnaris is defined and mobilized and brought around the outer border of the ulna and sutured to the extensor tendons of the three ulnar fingers.

A cock-up splint extending from the elbow to the metacarpophalangeal joints is applied and is to be worn for six months, while the muscles are reeducated by exercises.

Billington's technic utilizes the same muscle transference. Three incisions are made. The first incision exposes the pronator radii teres at its insertion. The second incision exposes the tendon of the flexor carpi radialis about 8 to 10 cm. above the wrist. The third incision is made along the ulna to the pisiform bone, and thence across the dorsum of the wrist to the base of the first metacarpal bone. The tendon of the pronator radii teres, after detachment, is inserted through buttonhole openings in the extensor carpi radialis longus and brevis tendons. The tendons are so sutured as to be under slight tension. The flexor carpi ulnaris tendon, after detachment, is passed around the dorsum of the ulna and passed through buttonholes in the extensor tendons of the four fingers The flexor carpi radialis tendon is passed through a buttonhole incision in the abductor pollicis longus and extensor pollicis brevis tendons, and sutured to these tendons. The distal end of the extensor

pollicis longus tendon is sutured to the flexor carpi radialis tendon. One of the objections to this tendon transference is that the power of wrist flexion may be unnecessarily weakened.

Inability to use the thumb in opposition decreases hand efficiency to a marked degree. The pincer action of the thumb may be lost following an injury or anterior poliomyelitis. Loss of opponens action not infrequently results from the latter when the thenar muscles are paralyzed. Restoration of opposition of the thumb by tendon transference has been accomplished by several methods.

Steindler makes an incision on the volar surface of the thumb from the middle of the end phalanx to the middle of the thenar eminence, along the ulnar border of the long thumb flexor. In order to avoid injury to such thenar branches of the median nerve as have escaped paralysis, this incision should go no further. The long flexor of the thumb is exposed, its sheath opened, and the tendon is split longitudinally into two halves (Fig. 803).

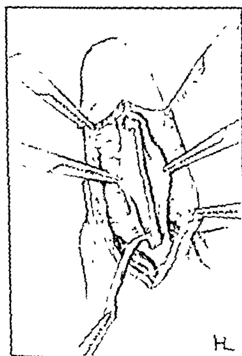


Fig. 803.



Fig. 804.

Fig. 803.—Steindler's operation for paralysis of opponens pollicis. Splitting the long flexor tendon of the thumb

Fig. 804.—Steindler's operation for paralysis of opponens pollicis. The radial half of the split flexor tendon of the thumb has been brought subcutaneously around to the dorsal surface of the proximal phalanx of the thumb and sutured to the periosteum there

The outer half of the tendon is divided at its insertion, reflected upward, and the sheath is sutured over the remaining ulnar half of the tendon. The radial tendon flap is carried around through a tunnel in the soft tissue to a point at the base of the proximal phalanx well onto its dorsum. A short incision is made at this point and the end of the tendon is fastened to the periosteum [illegible]
phalanx (Fig. 804). After the [illegible]

four weeks, and then exercises for it are started. As a result of this operation, when the flexor muscle of the thumb contracts, the transplanted portion of the tendon pulls the thumb into opposition.

*Bunnell's technic for restoration of opposition of the thumb* by tendon transference results in a more complete restoration than by the Steindler method. The two principles that Bunnell feels should be observed for accomplishing this rehabilitation are: (1) from the insertion in the thumb the tendon should pass subcutaneously in the direction of the pisiform bone; (2) the tendon should be inserted on the dorsoulnar side of the proximal phalanx of the thumb. Satisfactory results follow adherence to these two principles regarding the direction of pull and the tendon insertion to give pronation. Depending upon the available muscle and tendon, a considerable choice is offered if these two principles are followed. The palmaris longus may be used for motor power, and the extensor pollicis brevis may be used for the tendon. The tendon used can be passed around the flexor carpi ulnaris tendon, and when this is done a pulley construction is unnecessary.

The first incision is made along the volar surface of the wrist in the shape of an "L". The incision crosses the wrist along the distal flexor crease to the insertion of the flexor carpi ulnaris in the pisiform bone, thence proximally along this tendon. This tendon is exposed, and by blunt dissection a canal is formed about the tendon. Then the palmaris longus tendon is exposed proximally in the forearm at its musculotendinous junction. This tendon is severed at its palmar fascial insertion and is withdrawn from the incision in the forearm. A silk suture is placed through its end, and the tendon is passed subcutaneously toward the pisiform bone. Another incision is made over the metacarpophalangeal joint of the thumb on the radial side, exposing the extensor pollicis brevis tendon The musculotendinous junction of this tendon is exposed through an incision above the wrist. The tendon is divided at this junction and is withdrawn through the incision over the metacarpophalangeal joint of the thumb.

With a silk suture through the end of the tendon of the extensor pollicis brevis, the tendon end is passed subcutaneously across the thenar eminence toward the pisiform bone and is looped around the flexor carpi ulnaris tendon. Under adequate tension it is sutured to the distal end of the palmaris longus tendon with the thumb held in opposition. For three weeks the thumb is held in the position of opposition by means of a cast or a splint Motion and exercises are begun after removal of the cast. Adhesive strapping is excellent to maintain the thumb in opposition.

Tendon transference at the elbow and at the shoulder are unsatisfactory.

In the lower extremity, when the quadriceps is paralyzed and the knee flexors are not, the biceps may be transferred often with the semitendinosus. Before the operation is done, one must ascertain that all the flexor muscles of the knee are active, and preferably the gastrocnemius should not be paralyzed

An incision is made along the course of the biceps muscle on the outer side of the back of the thigh from its middle to below the knee (Fig 805). The muscle is isolated and detached from its insertion. Another incision is made anteriorly extending upward from the patella. The periosteum of the patella is incised and elevated and a groove made in the patella Immediately proximal to the patella an incision is made through the quadriceps tendon and a tunnel is formed from this incision to the outer side of the thigh. Through this tunnel the free end of the bi-

Fig. 805.—Transplantation of tendon of the biceps femoris. Exposure of the tendon, showing proximity of the nerve. (Sir Robert Jones.)

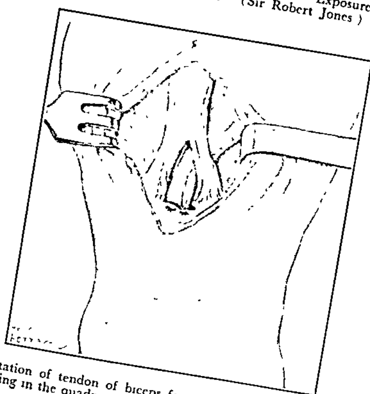


Fig. 806.—Transplantation of tendon of biceps femoris. The tendon is brought through an opening in the quadriceps tendon and sutured to the patella.

ceps is grasped with forceps and drawn forward through the opening in the quadriceps and, after thorough scarification, is fixed into the slot in the patella by chromic sutures, including the periosteum (Fig. 806). While this is done, the patella is pulled strongly upward in order to make tense the patellar tendon. If the semitendinosus is also used, it is exposed by a similar incision on the inner surface of the thigh, brought forward in a manner like that used for the biceps, and sutured with it to the patella. The periosteum of the patella is then closed over the tendons, and the wound is closed in layers. A plaster spica to the toes is applied for six weeks and then replaced by a posterior splint for six months. Exercises are begun after removal of the cast.

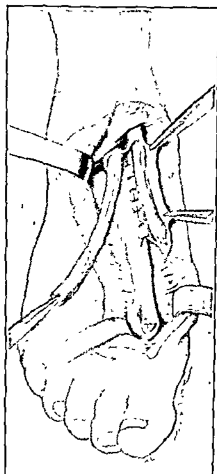


Fig. 807.—Steindler's transplant of extensor hallucis tendon for paralysis of the anterior tibial muscle The adjacent tendon sheaths have been opened and the opposing edges sutured together. The extensor hallucis tendon has been divided at the level of the metatarsophalangeal joint.

Tendon transference on the foot must nearly always be accompanied by arthrodesing operations Otherwise lateral imbalance will recur In our experience, in transference of the insertion of the tendon of an active muscle the object is more often to prevent its deforming pull than to replace the action of a paralyzed muscle For example, when a paralytic foot shows varus deformity through the pull of a strong anterior tibial muscle, while the peroneals are paralyzed, a bony stabilization operation should usually be accompanied by *transference of the insertion of the anterior* tibial tendon to a point near the middle of the foot

In certain selected cases, however, a tendon transference in the foot works well. The best results have been obtained in transference for paralytic pes valgus. If the

valgus deformity is solely from paralysis of the anterior tibial muscle, the posterior tibial being active, Steindler's method may be used.

An incision is made on the dorsum of the foot between the anterior tibial and the extensor hallucis tendons. The sheaths of these tendons are exposed and then opened by separate incisions. The opposing edges are sutured together to make the floor of a common tendon sheath (Fig. 807). The extensor hallucis tendon is divided at the level of the metacarpophalangeal joint, its proximal portion is scraped and sutured side to side to the anterior tibial tendon, while the end of it is fastened into a groove made into the internal cuneiform bone near the point of insertion of the anterior tibial (Fig. 808). The roof of the common sheath is made by suturing the mesotenon of the extensor to the remaining free edge of the sheath of the anterior tibial (Fig. 809). After the incision is closed in layers, the foot is put up at a right angle in plaster for three weeks, then a drop-foot brace is applied.

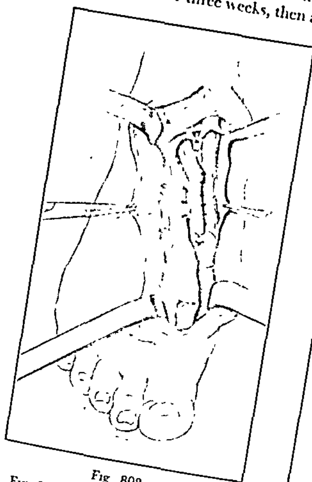


Fig 808

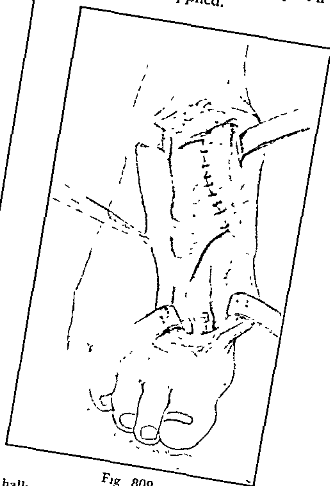


Fig 809.

Fig 808—Steindler's transplant of extensor hallucis tendon for paralysis of the anterior tibial muscle. The extensor hallucis and anterior tibial tendons, after being scraped, are sutured side to side, and the end of the extensor hallucis tendon is sutured to the bone.

Fig. 809.—Steindler's transplant of extensor hallucis tendon for paralysis of the anterior tibial muscle. Closure of the new common tendon sheath

If both anterior and posterior tibial tendons are paralyzed, it is usually better to do a stabilization operation on the foot In some clinics, however, the classical operation of Biesalski and Mayer, transplanting the peroneus longus to replace the anterior tibial, is performed.

An incision is made over the insertion of the anterior tibial with the convexity downward The tendon is dissected free, severed at its insertion, and a groove is

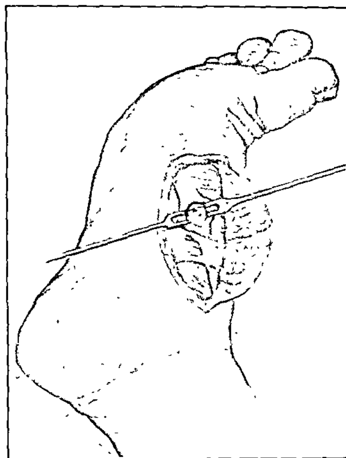


Fig 810.—Biesalski-Mayer transplant of long peroneal tendon A groove is made in the bone at the site of insertion of paralyzed anterior tibial tendon.

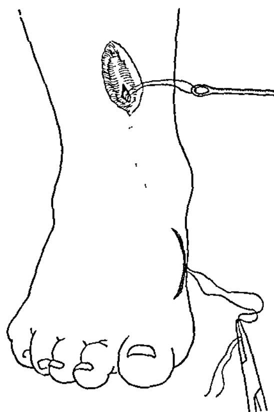


Fig 811.—Biesalski-Mayer transplant of long peroneal tendon Sketch to show incision over anterior tibial tendon above ankle and the long guide suture which is passed up the sheath to upper incision

formed in the bone under the periosteum for the reception of the long peroneal tendon (Fig. 810). Another incision is then made over the upper portion of the anterior tibial sheath above the ankle. A small opening is made in the sheath and a probe is passed down through it to the first incision. In the eye of the probe a long, strong guide suture of silk is inserted and carried to the upper incision with its free ends protruding below (Fig 811).

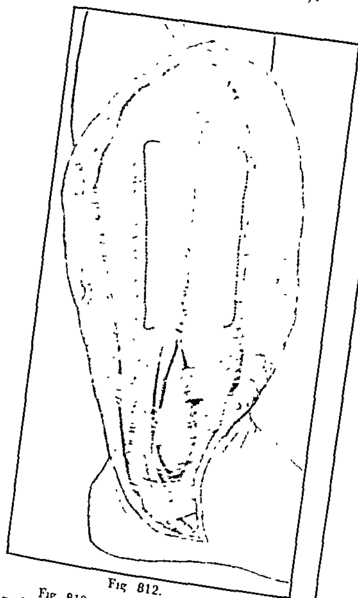


Fig 812.

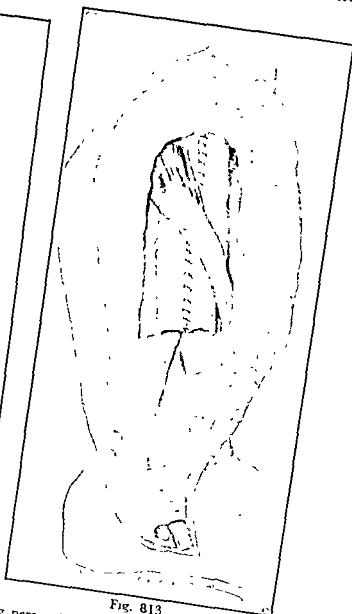


Fig. 813

Fig 812 —Biesalski-Mayer transplant of long peroneal tendon Incision exposing peroneal tendon and muscle The dotted lines show where incisions are made in the vaginal fascia over anterior and outer compartments of the leg

Fig 813 —Biesalski-Mayer transplant of long peroneal tendon. The peroneal tendon is drawn over the smooth gliding surface of the vaginal fascia from the outer to the anterior compartment of the leg

A long incision is made on the outer surface of the leg, exposing the full length of the tendons of the peroneal muscles. It is then necessary to make a bridge of smooth gliding tissue between the outer and anterior compartments of the leg over which the peroneal tendon may glide on its route to the anterior tibial sheath. Two parallel, longitudinal incisions are made, one over the outer and one over the anterior compartment, with the intermuscular septum between the incisions (Fig. 812). Small

cross incisions are made at each end of the longitudinal incisions and the vaginal fascia is thus mobilized and turned over so as to bring its smooth undersurface on top. The two edges of the deflected surface are united by fine sutures (Fig. 813). The divided anterior tibial tendon is drawn up through its sheath, pulled out through the upper incision, cut off, and discarded.

The peroneus longus tendon is then divided at the outer border of the foot and rapidly freed all the way to the upper border of the long lateral incision. The upper end of the guide suture is brought out from the anterior to the lateral incision over the fascial bridge, and the peroneus longus tendon is hooked into its loop. The guide suture, carrying the tendon, is made to retrace its course and bring the tendon through the empty anterior tibial sheath to the lower or median incision in the foot. The tendon is anchored here in the slot made for it and the periosteum is sutured over it (Fig. 814). All incisions are closed in layers and plaster is applied from above the knee to the toes with the foot inverted and dorsiflexed. After three weeks a brace is applied, holding the same position No weight-bearing is allowed for several months and then only with the brace, but exercises are started early.

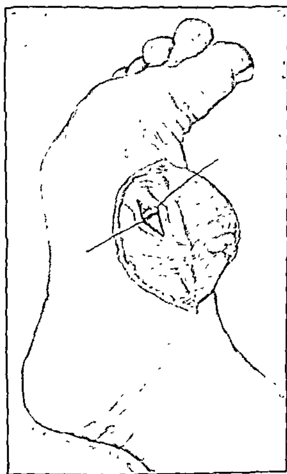


Fig. 814




Fig 815.

Fig 814 —Biesalski-Mayer transplant of long peroneal tendon The end of peroneal tendon is sutured into the previously prepared groove

Fig 815 —Line of incision for Steindler's stripping of the os calcis

In certain cases of cavus deformity, transplanting the long extensor tendons of the toes into the metatarsal bones is useful. This operation relieves the hyperextension deformity of the toes from the pull of the tendons and allows better mechanics

for their action as dosiflexors of the foot. But it must always be preceded by Steindler's stripping of the os calcis. This very helpful procedure is performed through an incision over the inner aspect of the os calcis, extending forward 3.75 cm., in front of the inner tubercle of this bone (Fig 815). The plantar surface of the plantar fascia is exposed and the fascia is divided transversely close to where it is attached to the lower surface of the os calcis. The muscles attached to the os calcis are then stripped off its periosteum with a heavy, blunt periosteal elevator forward to the calcaneocuboid articulation. After this, more correction of the cavus is obtained by wrenching the foot.

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# CHAPTER 66

# OPERATIONS ON JOINTS

M. Josiah Hoover, Jr.

## ASPIRATION AND DRAINAGE OF JOINTS

The introduction of antibiotics has not significantly changed the indications for incision and drainage of joints, although a more conservative attitude can now be assumed.

For many years, even after the advent of asepsis, operations on joints, other than incision for drainage, were often attended with disaster. Infection occurred so frequently that even now when an arthrotomy is advised, usually the first question the patient asks is whether the joint will be stiff.

With a better knowledge of the physiology of synovia and realizing that synovial membrane does not have such protective powers against bacterial invasion as does the peritoneum, the surgeon has learned that most rigid asepsis is necessary in operations on joints With this remembered and with careful technic, there should be no more chance of infection when a joint is opened than when an incision is made into the body elsewhere.

The simplest joint operation is aspiration for the removal of excess fluid from the joint, which is usually done for diagnosis. It also serves for the purpose of irrigation and for instillation of therapeutic agents This often obviates the necessity for incision and drainage.

In the shoulder the two points best suited for entrance of the aspirating needle are anteriorly over the joint between the inner border of the deltoid and the outer border of the pectoralis major or laterally just under the acromion process, pushing the needle downward, inward, and slightly backward (Fig 816).

For aspirating the elbow, the needle is introduced posteriorly into the space between the olecranon and the lateral condyle (Fig. 817).

At the wrist, the needle is inserted dorsally just beyond the distal end of the radius between the extensor pollicis and extensor indicis tendons

When aspirating the hip, the femoral artery is palpated, or, if it cannot be palpated, is located by running a line from the anterior superior spine to the symphysis pubis At the mid-point of this line is the head of the femur and from 2 5 to 5 cm internal to it is the artery When the artery is located, the needle is inserted directly backward at a point 5 cm lateral to it (Fig. 818).

For aspirating the knee, a point just lateral or just medial to the patella may be selected, with the needle directed somewhat obliquely (Fig 819).

When the ankle is punctured, the needle is introduced anteriorly into the joint either between the lateral border of the extensor digitorum tendons and the external

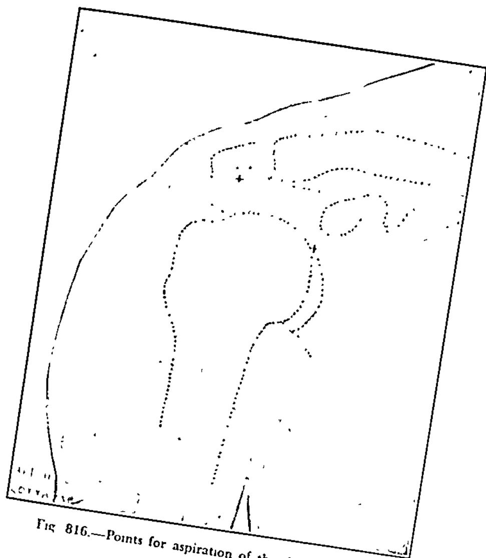


Fig 816.—Points for aspiration of the shoulder joint.

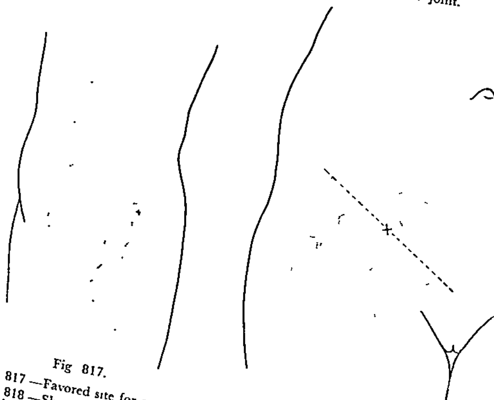


Fig 817.

Fig 818.

Fig 817 —Favored site for aspiration of the elbow joint

Fig 818 —Sketch to show the position of head of femur (x) The femoral artery must be located before aspiration of the hip joint.

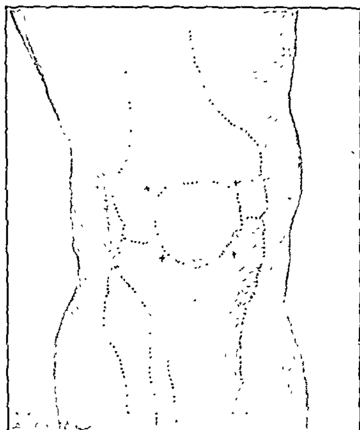


Fig. 819.

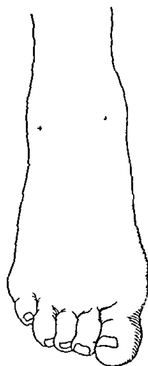


Fig. 820

Fig. 819.—Points for aspirating the knee joint.
Fig 820 —Points for aspirating the ankle joint

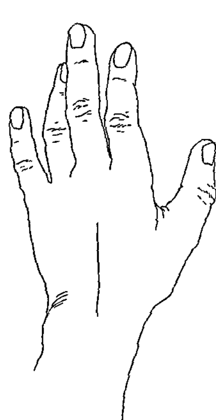


Fig 821.

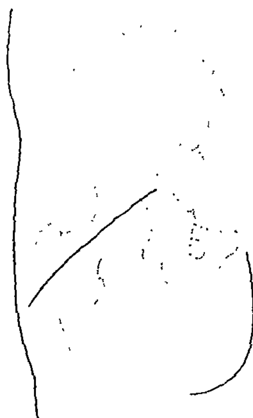


Fig 822

Fig 821 —Line of Langenbeck's incision for opening the wrist joint
Fig 822 —Ober's posterior incision for drainage of the hip

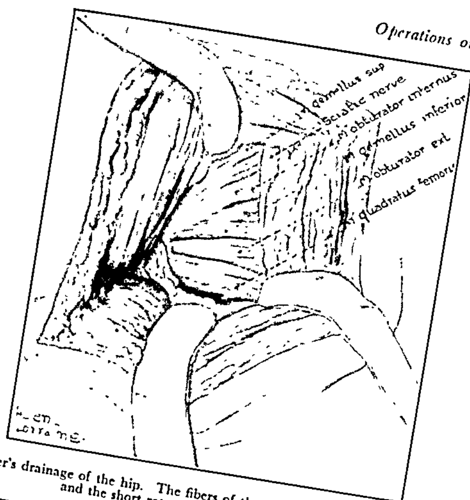



Fig. 823.—Ober's drainage of the hip. The fibers of the gluteus maximus have been separated and the short rotators of the hip are exposed.

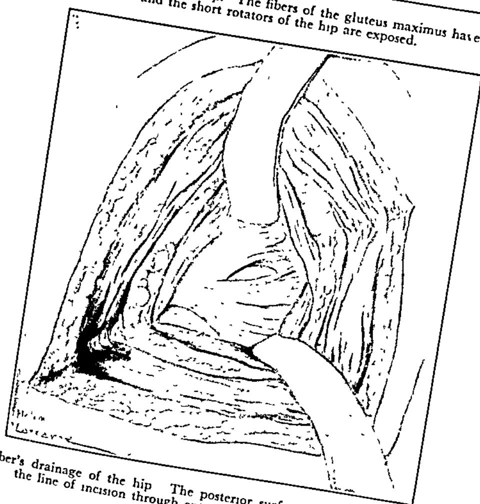


Fig. 824.—Ober's drainage of the hip The posterior surface of the capsule is exposed and the line of incision through entire length of capsule is shown

malleolus or between the medial border of the anterior tibial tendon and the internal malleolus. It is directed backward and slightly downward (Fig. 820).

If pus, unless it be tuberculous, is obtained by aspiration, the joint usually must be immediately drained. Good dependent drainage of the shoulder is obtained by an anterior axillary incision along the lower border of the pectoralis major muscle. The elbow may be drained by posterior incisions on either side of the triceps tendon, the course of the ulnar and radial nerves always being remembered by the operator. The wrist is best drained by the dorsal incision of Langenbeck (Fig. 821).

For draining the ankle joint, anterointernal and anteroexternal incisions are recommended. If it is necessary to add a posterior incision, it should be made external to the Achilles tendon.

Drainage of the knee is instituted through an incision on either side of the patella. Here, as in incision and drainage of all joints, the incision should be kept open by a drain extending down to but not within the synovial layer of the capsule.

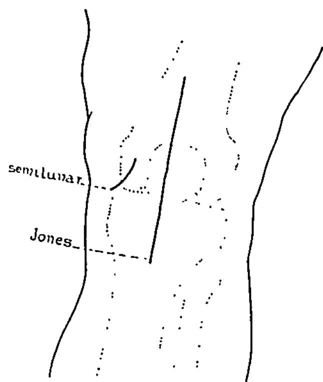
For draining the septic hip, Ober offers an excellent and anatomy-respecting operation. An incision is made posteriorly in line with the neck of the femur, beginning at the posterolateral aspect of the femur and extending obliquely upward and backward toward the sacrococcygeal articulation (Fig. 822). The fibers of the gluteus maximus muscle are separated, exposing a layer of fat containing anastomosing vessels. The sciatic nerve should then be identified in the medial angle of the incision. By blunt dissection this fatty layer is separated and the short rotator muscles are exposed (Fig. 823). These are separated by blunt dissection, down to the posterior aspect of the capsule of the hip. The capsule is split throughout its whole length, so that the acetabulum and the femoral neck are freely exposed (Fig. 824). If pus is present, a cigarette drain is sutured to the outside of the capsule on either side of the incision. Being posterior and dependent, these drag the capsule into a funnel shape and allow good drainage.

## ARTHROTOMY IN THE NONSEPTIC JOINT

### Knee

Arthrotomy is, of course, done for many other reasons than draining a septic joint. Because of the frequency of mechanical derangements in the knee, this joint is probably more often opened than any other.

For the free exposure of the knee joint, necessary, for example, when there are multiple loose bodies or when a synovectomy is to be done, there are two excellent incisions Jones' patella-splitting incision undoubtedly gives the fullest exposure. A longitudinal incision, beginning 7.5 to 10 cm. above the upper border of the patella, slightly to the inner side of the midline, parallels the fibers of the rectus femoris and extends downward over the patella to the insertion of the quadriceps tendon (Fig 825). The patella is split longitudinally with a saw or broad osteotome and the split is continued upward through the quadriceps tendon. The joint is thus widely opened and when the knee is flexed and retractors are placed on each side of the incision, the whole interior, except the posterior compartment, is exposed After the synovia is closed with fine catgut, the two halves of the patella are firmly approximated and held by interrupted sutures of chromic catgut passed through the fibrous extension of the quadriceps tendon which covers the patella The split tendons are sutured and the skin is closed.



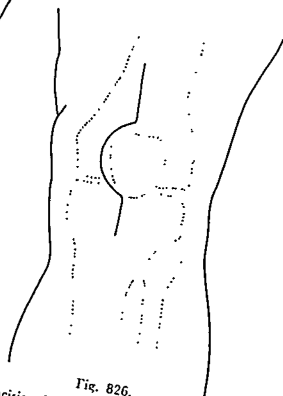




Fig. 825.—Jones' patella-splitting incision and incision for removal of internal semilunar cartilage of the knee.

Fig. 826.—Krida's "general utility" incision of the knee.

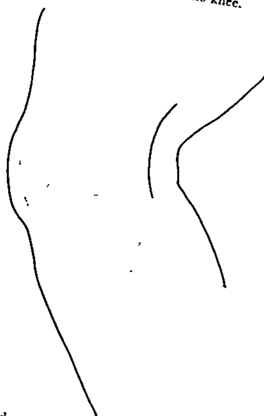


Fig 827.—Henderson's posteromesial incision of the knee

The disadvantages of this incision are that it requires several weeks of immobilization for healing of the patella and that an irregularity of the articular surface of the patella in the line of incision sometimes occurs, with the danger of a subsequent traumatic arthritis.

Krida's "general utility" incision has neither of these disadvantages and allows adequate exposure, though the exposure is not quite as ample as through the Jones incision. The upper line of incision is the same, but at a point about 1.25 cm. above the patella, it curves around the patella, continuing downward, and about 1.25 cm. medial to it, until at its lower border it follows the inner border of the patellar tendon (Fig. 826). By deepening the incision, the subquadriceps bursa and the knee joint proper are opened, the knee is then flexed, and the patella is retracted strongly outward. This incision may also be made to the outer side of the patella.

If the knee joint is to be opened for the removal of an injured semilunar cartilage, so large an incision is neither necessary nor advisable. The internal semilunar is usually the cartilage injured and in the majority of cases only the anterior two-thirds is involved. Using a tourniquet and with the knee flexed at a right angle over the end of the operating table, an incision 5 to 7.5 cm. long begins about 2.5 cm. medial to the internal border of the middle of the patella and extends downward, curving slightly backward in the line between the femur and the tibia (Fig. 825). Some surgeons prefer a straight incision, others prefer one curving slightly forward. The fibrous and synovial layers of the capsule should be identified and opened separately, as this facilitates more nearly perfect closure. Blunt retractors are then used and the inner half of the anterior compartment is inspected. Usually, the semilunar cartilage is found either to be fractured transversely in its anterior third or to be split circumferentially, or a combination of the two may be present. The cartilage is divided at its anterior attachment, grasped with a strong forceps, and gentle traction forward is made on it. With a knife or blunt-pointed scissors it is cut from its peripheral attachments and removed Always from two-thirds to three-fourths of the entire cartilage may be removed in this manner and frequently the entire cartilage may be drawn into the anterior compartment by gentle traction, especially when the lesion is a "bucket handle" split. A careful inspection of the joint is made for other injuries and then the capsule is closed with fine catgut for the synovial layer, chromic for the fibrous layer, and the skin is sutured with interrupted nonabsorbable sutures. A compression gauze dressing is applied before the tourniquet is removed, and sometimes a posterior splint is kept on for twenty-four hours

Where the posterior portion of the cartilage is injured, it may be exposed through the posteromesial incision of Henderson (Fig. 827) The cartilage is divided at its posterior insertion and the entire meniscus may then be drawn into the anterior compartment of the joint and excised through the anterior incision.

In the relatively rare case of injury to the external semilunar cartilage, the technic of removal is the same with the incision to the lateral side of the patella.

Bosworth, after reoperating on three knees in close succession and in each case having to remove the posterior third of the semilunar cartilage, incompletely removed at a previous operation, concluded that in all cases the entire meniscus should be excised.

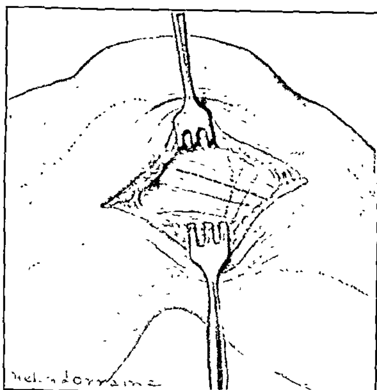


Fig. 829.—Bosworth. Anterior incision in capsule of knee.

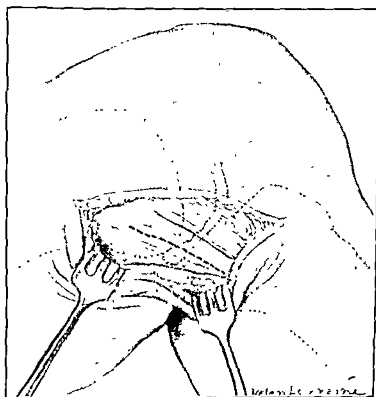


Fig. 830.—Bosworth. Posterior incision in capsule of knee.

over the inner side of the joint, extending from the adductor tubercle of the femur to 10 cm. below the articular surface of the tibia. This is carried through the skin and fascia, which are dissected backward and forward, so that the structures can be retracted and the whole of the inner side of the capsule and of the head of the tibia can be exposed. With a broad chisel, the inner side of the head of the tibia, with the lateral ligament attached, is removed and reflected upward. This section of bone is from 3 to 5 cm. in length and about 1.25 cm. thick at the articular surface, and is triangular in shape. At the joint surface the capsule is split upward for about 2.5 cm. at both the anterior and posterior margins of the bone flap. As the flap of the capsule with the bone attached is reflected, the internal semilunar cartilage (if it has not been removed) will be seen to be attached to the flap but still bound to the head of the tibia at its anterior and posterior ends. After full reflection the cartilage is removed with scissors from its attachment to the inner aspect of the flap. When the flap is fully turned up, the whole inner aspect of the joint is exposed and, by flexion and abduction of the leg on the thigh, the fat pads, the crucial ligaments, and the interior of the joint in both the anterior and posterior aspects can be examined.

To shorten the ligament, the ligament and bone flap are drawn strongly downward and the point to which the articular surface of the bone flap can be brought is marked by a chisel cut. This distance averages 2 cm. with a maximum of 3 cm. Five-tenths of a centimeter below this point a notch is chiseled in the side of the tibia according to the depth and width of the bone flap Additional bone is then removed from below to accommodate the flap. At the lower end a small shelf of overhanging bone is left, under which the lower end of the transplanted bone flap can be slipped and locked. This fixation may be maintained by placing a screw through the bony attachment of the ligament. The upper margin of the area of the tibial end is beveled upward and inward, and the upper articular surface of the bone flap is denuded of the cartilage by beveling downward and outward. The bone flap is then mortised into the new bed and locked by slipping the lower end of the flap, which has been slightly shortened, under the overhanging shelf of bone. It should be noted that the part of the ligament formed by scar tissue is brought against the denuded bone of the tibial head above the new bed. The inner surface of this part of the capsule should be scarified, so that in healing it will be firmly adherent to the bone and entirely eliminated from the shortened ligament.

The whole bone flap can be implanted forward on the new bed if one wishes to increase the obliquity of the anterior fibers of the ligament which might act as an additional check on any forward movement of the tibial head on the femur.

The anterior and posterior incisions of the capsule are closed with catgut. Plication of the capsule by overlapping of the edges of these incisions with mattress sutures would strengthen the inner side of the capsule if this is thought necessary. The skin is closed in the usual manner. A hinged cast is applied. The knee is kept quiet for the first two weeks, and the patient is then allowed to be up, using the leg and taking graduated exercises for the development of the quadriceps. The hinged cast is retained for six weeks.

It is rare that it is necessary to repair surgically a ruptured crucial ligament. When this is needed in the occasional case, Hey Groves' procedure or one of its various modifications is advised. In this operation a long strip of fascia lata is

passed through a drill hole in the femoral condyle and another in the tibial tuberosity, appropriately placed to follow the course of the anterior or posterior crucial ligament as desired.

A crucial ligament injury usually heals satisfactorily, when seen early, by prolonged immobilization of the knee joint.

**Recurrent Dislocation of the Patella.**—Although the operation to correct this condition is not truly an arthrotomy, as the joint is not opened, it will be described here. The patella dislocates outward over the external femoral condyle and there is usually a relaxation of the patellar tendon and a redundancy of the medial portion of the capsule of the knee.

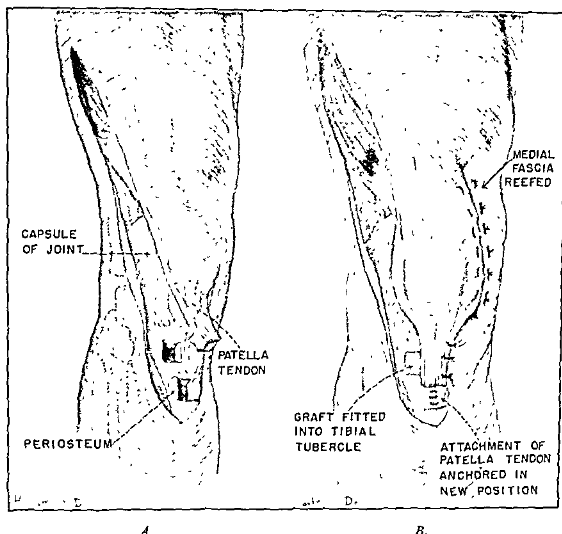



Fig 831.—*A*, Operation for recurrent dislocation of patella, according to Hauser. The *tendon, having been freed, is removed with its bony attachment. B,* Hauser operation completed. Distal and medial attachment of patellar tendon by countersinking in similar bony defect The medial fascia is reefed (Redrawn from Hauser· Surg, Gynec. & Obst. 66: 199, 1938 )

A modification of Goldthwait's operation is used. An incision is made on the inner side of the patella and its tendon. The capsule and the tendon are exposed and the tendon is split longitudinally The outer half of the tendon with the portion of the tibial tuberosity to which it is attached is freed and passed backward under the inner half Its bony attachment is fixed into a slot in the tibia at the inner side of the anterior surface of the tibia. The medial half of the capsule is

plicated with several mattress sutures of catgut. The incision is closed in the usual manner and the limb is splinted with the knee extended.

The procedure described by Hauser is efficient and well devised. The patellar tendon is exposed through an anterolateral incision that extends below the tibial tubercle 1.25 cm. (Fig. 831). The tendon is freed by blunt and sharp dissection from its attachment at the tibial tubercle. With an osteotome the insertion is removed with a block of bone. The patella is freed along its lateral attachment down to the synovial membrane so as to allow the tendon to be pulled medially. This dissection is done without entering the joint. A block of bone the size of the tendon attachment is removed from the most medial and distal site to which the tendon can be pulled. The tendon insertion with its block of bone is countersunk into the square hole and fixed by one screw, or chromic catgut sutures may be used for fixation. The bone block space at the tibial tubercle is filled with the second graft that was removed. A plaster cast is worn for ten to fourteen days. At the end of four weeks the patient is permitted to walk with the knee extended. Free flexion is permitted at the end of six weeks.

## Hip

For operations on the hip joint other than drainage, the Smith-Petersen incision has been found most useful. From a point 7.5 or 9 cm. distal to the anterior superior spine, a vertical incision, following the external border of the sartorius muscle, is made upward to the spine of the ilium and thence backward along and just outside of the iliac crest for several centimeters as desired (Fig. 832). The insertions of the gluteus medius, gluteus minimus, and tensor fasciae femoris muscles are stripped subperiosteally from the dorsum of the ilium with a sharp elevator, and the joint is exposed by blunt dissection through the intermuscular plane between the sartorius anteriorly and the tensor fasciae femoris posteriorly (Figs. 833 and 834). Incision is then made into the superior portion of the capsule. After the capsule is closed, the stripped muscles are sutured back to the iliac crest and the portion of the incision in the thigh is closed in the usual manner.

This incision is used for the open reduction of congenital dislocation, for arthroplasty, for most arthrodesing operations, and for shelf operations to stabilize the hip.

Smith-Petersen has changed this incision in recent years to allow a much better exposure of the hip joint The skin and fascial incisions are unchanged, extending along the anterior third of the iliac crest and the lateral border of the sartorius (Fig. 835). The attachment of the direct head of the rectus to the anterior inferior spine is then defined.

Between the origin of the abdominal oblique and the sartorius muscles mesially and the gluteus medius and the tensor fasciae femoris muscles laterally is a definite sulcus which should be defined before the periosteum is incised and reflected from the anterior iliac crest and the anterior superior spine (Fig. 836). By incising the periosteum between the anterior superior and anterior inferior spines the iliacus can be reflected subperiosteally from the iliac fossa. A blunt instrument is then inserted mesial to the anterior inferior spine in order to get a lead to the plane of division between the main portion of the iliacus muscle and its marginal portion. The tendon of the rectus femoris is divided (Fig. 837) just below its origin from the anterior inferior spine and reflected from the anterior capsule; it is temporarily

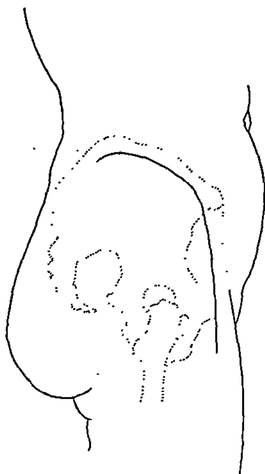


Fig. 832.—Smith-Petersen approach to the hip joint. Line of incision.

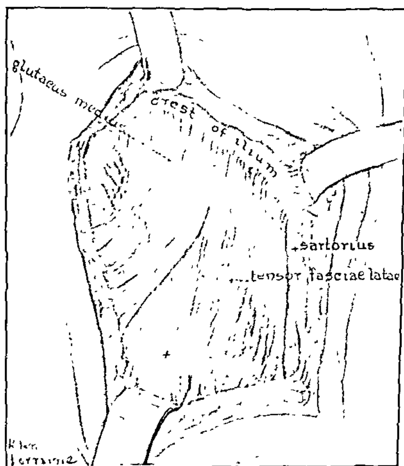



*Fig. 833.—Smith-Petersen approach to the hip joint. The skin has been retracted, showing the anterior two-thirds of the crest of the ilium and the muscles attached to it.*

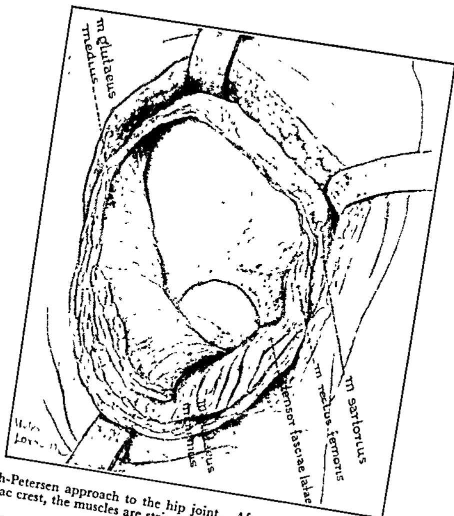



Fig. 834.—Smith-Petersen approach to the hip joint. After their attachments are cut through close to the iliac crest, the muscles are stripped away from the ilium to expose the hip joint.

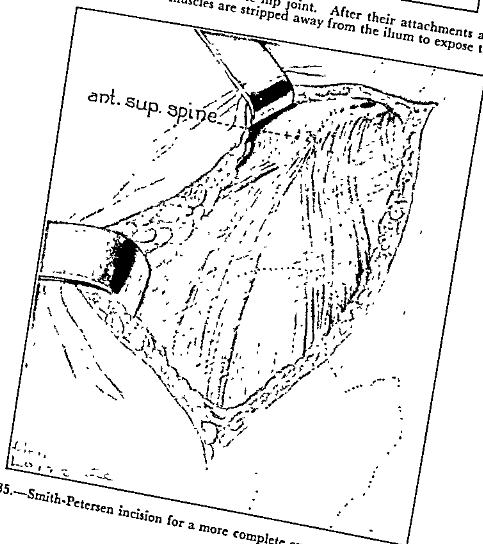



Fig. 835.—Smith-Petersen incision for a more complete exposure of the hip joint.

sutured to the inferior angle of the incision in order to keep it retracted without traumatization. At times it becomes necessary to reflect the origin of the tensor fasciae femoris and gluteus medius from the lateral aspect of the ilium in order to facilitate the dislocation of the femoral head (Figs. 838 and 839).

Since this approach follows structural planes, the closure is simple. The rectus femoris is sutured to its proximal stump; this brings its posterior tendinous surface in apposition to the femoral neck. Suturing the periosteum of the iliac crest to the *origin of the muscles arising from the lateral aspect of the ilium allows the sartorius* and the iliacus to drop back over the mesial portion of the joint.

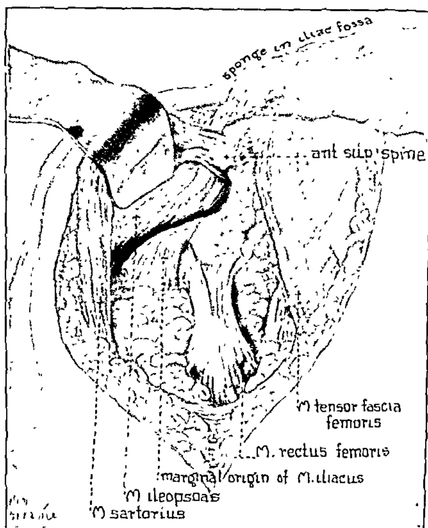



Fig. 836.—Smith-Petersen approach to the hip joint

In the majority of cases of congenital dislocation of the hip, the hip can be reduced by closed methods if the patient is less than four years old. If it cannot, after traction, the joint is exposed by the Smith-Petersen incision. The capsule is *incised longitudinally and the* incision is enlarged by transverse cuts. The thigh is flexed and the index finger is introduced into the capsule to find the acetabulum. Usually an hourglass constriction is felt and this is divided by a blunt-pointed knife inserted cautiously along the finger. The acetabulum can now be seen, and by rotation and abduction, sometimes using a bone skid, the femoral head is *lifted* forward into the acetabulum. The best position for stability is found, the wound is closed, and a plaster spica is applied with the limb in the selected position. In

some cases of congenital dislocation of the hip the reduction at the time of open reduction can be obtained only by internal rotation of the lower extremity. This is due to the anteversion of the femoral neck. Four weeks after the reduction a second-stage operation must be performed. At this operation a subtrochanteric osteotomy is done in order to correct the internal rotation. The osteotomy is carried out within a periosteal sleeve. This helps to maintain the position of the fragments and does not prevent the derotation. A supracondylar osteotomy may be preferred.

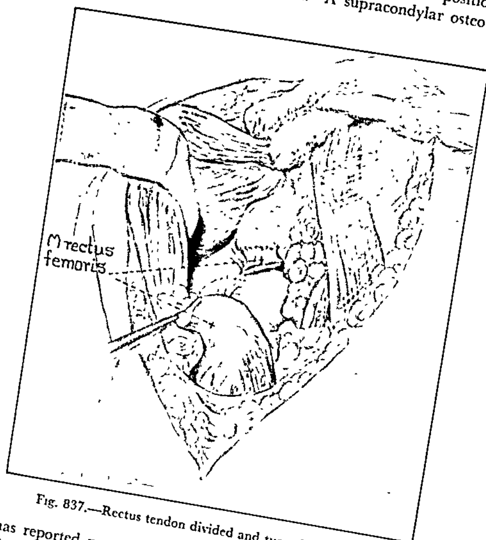



Fig. 837.—Rectus tendon divided and turned downward.

Crego has reported much success in reducing congenitally dislocated hips by Kirschner wire for skeletal traction. Not only is skeletal traction used to pull the dislocated femoral head down to the acetabular level before an open reduction is performed, but he uses it preliminary to closed reduction, sometimes accomplishing the reduction by this means alone.

In irreducible dislocation, where telescoping causes pain and disability, in certain cases of healed but unstable pathologic dislocations or dislocations following anterior poliomyelitis, the procedure of stabilization by a bony shelf above the dislocated head is of value. In these instances an attempt to bring the displaced femoral head down to the level of the acetabulum usually fails. Instead, a U-shaped incision is outlined in the periosteum of the ilium with the base downward, just above the head of the femur. With a motor saw or a thin, broad osteotome, a broad bone flap is cut from the outer table of the ilium, as outlined in the perios-

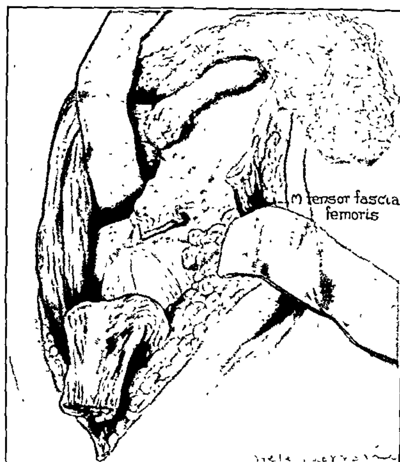



Fig. 838.—Exposure of capsule.

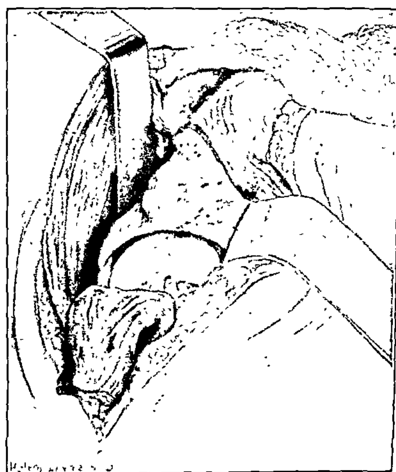


Fig. 839.—Acetabulum and head of femur exposed.

teum, with base downward. It is carefully pried outward, with the endeavor to cause a greenstick fracture at its base and to have it serve as a shelf above the femoral head. The flap is held down by a graft taken from the iliac crest and wedged between the flap and the upper border of its former site, and the triangular space left is filled in with multiple chip grafts taken from the ilium near its crest. After wound closure, the limb is immobilized in moderate abduction by a plaster spica for the period necessary for firm healing, which is usually two or three months, before weight-bearing is allowed. From the study of A. R. Smith, the shelf operation in patients under ten years of age would seem of questionable value.

Compere advises making the shelf with tibial pegs but says the result in any shelf operation is unsatisfactory unless the dislocation is first reduced.

A full thickness autogenous tibial graft 1.25 cm. in width and 15 cm. in length should be obtained by assistants and divided into four segments 3.75 cm. in length. The edge of three of these grafts should be sharpened to resemble the cutting edge of a chisel.

Using first an osteotome and then a thick-bladed chisel which is placed at the superior rim of the primary acetabulum just above the reduced head of the femur and outside of the capsule, a deep arched groove is prepared for the grafts. The chisel should be driven into the edge of the acetabulum and on into the ilium for a distance of more than 1.25 cm. in a medial and upward direction.

Each of the three grafts is now driven firmly into the slot. One is placed slightly anterior, one directly above, and one slightly posterior to the head of the femur, with the edges of each of the three grafts in contact with the graft adjacent to it.

The remaining segment of tibia and additional bone from the ilium are now placed in the angle between the ilium and the firmly impacted tibial pegs.

The shelf thus formed prevents the reduced femoral head from dislocating. Traction must be maintained after the operation in order to prevent pressure of the reduced head against the acetabular roof or the tibial peg shelf, as this pressure may cause aseptic necrosis.

## Shoulder

Except for fractures or for stabilization of the joint, the shoulder is rarely opened. However, there is one condition for which it should always be opened, as the disability attending it is marked. This condition is recurrent dislocation of the shoulder. Numerous operations have been proposed to remedy this, most of them being directed to the repair of the anteroinferior portion of the capsule, which is slack and will not retain the head of the humerus in contact with the glenoid when the arm is abducted. Capsulorrhaphy is the operation most frequently done but it often fails to prevent the dislocation.

Henderson has proposed "slinging" the humerus to the coracoid by passing a loop of peroneal tendon through a drill hole in the head of the humerus and suturing the ends of the loop together over the coracoid.

Nicola's operation is simple and the end results are satisfactory. The incision begins just outside of the coracoid and passes downward for 6.75 cm in the line of the fibers of the deltoid (Fig. 840). These are separated by blunt dissection, carefully avoiding the circumflex nerve and artery. The tendon of the long head



Fig. 840.—Nicola's operation for recurrent dislocation of the shoulder. Line of incision.

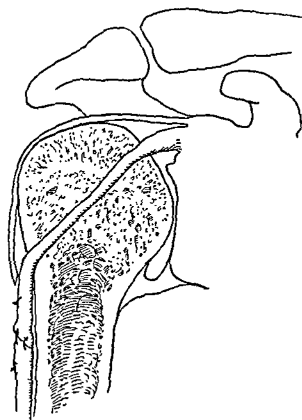


Fig. 841.—Nicola's operation for recurrent dislocation of the shoulder Sketch to show the divided tendon of the long head of the biceps humeri drawn through tunnel in head of humerus and sutured to the distal portion of tendon.

of the biceps is palpated in the bicipital groove and is exposed into the shoulder joint by dividing the transverse humeral ligament, which covers it in the groove, and by splitting the capsule above it. The tendon is then divided about 2.5 cm. below the transverse humeral ligament, after stay sutures of silk have been placed in its proximal and distal parts. The elbow is flexed at 45 degrees and kept so for the rest of the operation.

With a 0.5 cm. gouge or drill, a hole is made through the head of the humerus, beginning in the bicipital groove and directed so that it comes out on the articular surface of the head of the humerus in the line of the tendon, from 1.25 to 1.8 cm. from the edge of the articular cartilage. A flexible probe is passed through the tunnel from the proximal end and is threaded with the silk attached to the proximal part of the divided tendon. After removing the synovial covering from the tendon, the tendon is drawn through the tunnel by the probe and united to the distal part of the tendon with the silk stay sutures (Fig. 841). With the arm abducted to a right angle, the transverse humeral ligament is sutured to that part of the tendon which lies in the bicipital groove.

The transverse humeral ligament and the capsule are sewed with continuous No. 1 catgut sutures and the skin with the suture preferred. The shoulder is dressed with a simple Velpeau bandage, reinforced with adhesive plaster, with the arm close to the chest and the elbow flexed to 45 degrees. This position should be maintained for three weeks, in epileptics for six weeks.

Bankhart asserts that ordinary dislocation of the shoulder and recurrent dislocation are entirely different injuries. The former is caused by a fall on the abducted arm, levering the head of the humerus out through the inferior part of the capsule, which heals readily after reduction. The latter injury is caused by a fall on the back of the shoulder or on an elbow directed backward, which forces the head of the humerus forward and shears off the fibrocartilaginous glenoid ligament from its attachment to the bone. There is no tendency for this ligament to reattach itself to the bone, so the defect is permanent. The exposure is made by approaching between the deltoid and the pectoralis major muscles. The coracoid process is divided by an osteotome and pulled downward. The tendon of the subscapularis muscle is exposed and divided, showing the joint capsule. The periosteum is raised over the anterior aspect of the neck of the scapula, and the joint capsule and glenoid ligament are sutured to the bare bone thus exposed.

DePalma is of the opinion that the Magnuson procedure for recurrent dislocation, properly performed, will supplant all other methods. External rotation is limited by transferring the subscapularis tendon from the lesser to the greater humeral tuberosity The limited external rotation is the essential feature of the operative procedures for redislocation. The Magnuson method is effective and is the simplest procedure to accomplish limitation. He points out the fact that the transference of the tendon counterbalances the pull of the pectoralis major, latissimus dorsi, and teres major muscles. DePalma has modified the operation by anchoring the subscapularis tendon at a lower level on the humeral shaft (Fig. 842). By an S-shaped incision on the anterior aspect of the shoulder the tendon of the subscapularis is exposed This tendon's borders are outlined by two parallel incisions, and it is freed from the lesser tuberosity. The arm is internally rotated, bringing into the view the greater tuberosity. A slot is made below this tuberosity with an osteotome so that the tendon will fit into the osseous groove. Through drill holes in the bone slot the tendon is fixed with mattress silk sutures. By side-to-side sutures

the upper border of the subscapularis muscle is approximated to the supraspinatus muscle. Its lower border is sutured to the capsule beneath the humeral head. The wound is closed in layers. For two weeks a plaster of Paris shoulder swathe is worn. Then a sling is used for two weeks. After eight weeks, motion is resumed without restrictions.

*Operation for Repair of Ruptured Supraspinatus Tendon.*—DePalma's studies have shown that the role of the supraspinatus muscle in elevation and abduction of the limb is a minor one. For repair of rupture of the supraspinatus tendon in the shoulder, Spaulding uses an incision on the anterior aspect of the shoulder extending downward from the acromioclavicular joint for 7.5 cm. The deltoid fibers are bluntly separated, the subdeltoid bursa is exposed and incised in the same direction as the skin.

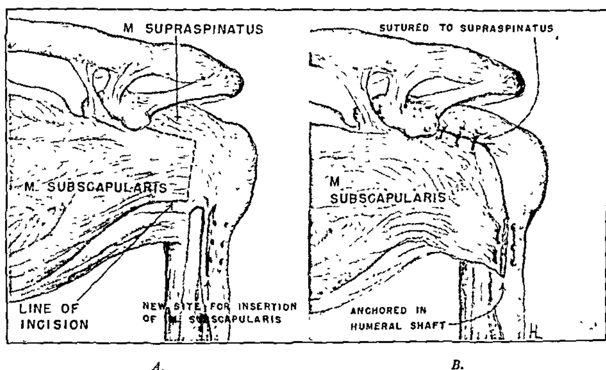



Fig. 842.—*A, The modified Magnuson operation for recurrent shoulder dislocation.* The subscapularis tendon is freed from the lesser tuberosity. *B,* External rotation is diminished by transferring the tendon to a slot in the shaft below the greater tuberosity, paralleling the posterior lip of the bicipital groove. (From DePalma, A. F.: Surgery of the Shoulder, J. B Lippincott Co, 1950.)

Upon opening the bursa, the supraspinatus tendon appears, usually torn at its insertion and retracted beneath the acromion for a variable distance. It is often very difficult to recover the retracted tendon in the small working space, and Spaulding uses a special doubly curved hook for this purpose, while an assistant pulls the arm downward and outward. With an osteotome, the sulcus between the articular cartilage and the greater tuberosity is deepened to provide an abutment for the anchorage of the end of the tendon. This gutter is about 2.5 cm. long, 0.5 cm. broad, and 1.25 cm. deep Four drill holes made through the lateral surface of the humerus below the greater tuberosity into the gutter serve to fix the tendon in its bed.

The edge of the thickened supraspinatus is then inserted into the gutter and secured by a running double mattress suture of heavy silk. This suture is inserted inward through hole No. 1, piercing the tendon, out through hole No. 2, in hole

No. 3, out hole No. 4, then back in No. 3, out No. 2, and then square knotted outside between holes 1 and 2. An odd number of holes should not be made as then the tie will terminate inside. The capsule is then closed with interrupted sutures of catgut and the skin with absorbable sutures. The extremity is immobilized in a plaster spica, the arm in 90° abduction and external rotation, with the elbow at a right angle.

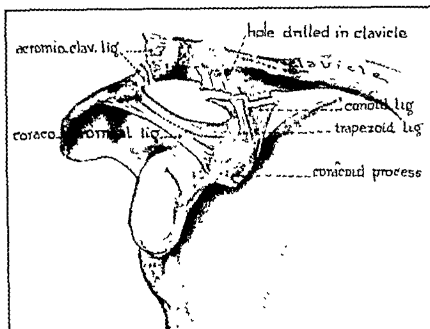



Fig. 843.—Line of division of coraco-acromial ligament.

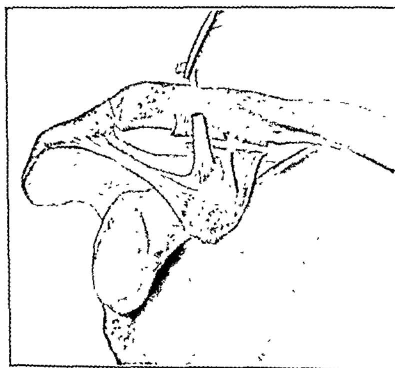


Fig 844—Posterior portion of coraco-acromial ligament carried through drill hole in clavicle.

In contradistinction to the method employed by Codman of making a saber incision, Spaulding has found that, where the tendon has retracted so far back that it cannot be found or is more or less atrophied, by making a small incision above the

superior border of the spine of the scapula into the supraspinatus fossa and following the supraspinatus muscle down toward its tendon attachment, he was able to obtain the severed end rather readily. He believes this procedure causes less anatomic damage and is preferable to impairing the security of the clavicle and the acromioclavicular joint.

The plaster is worn with the arm in the original position for three weeks, the arm is then fixed at 75 degrees for a few days and is gradually lowered to the dependent position in an additional week. Physiotherapy is given, but active abduction is permitted with caution.

McLaughlin repairs massive avulsions of the cuff through a saber incision after Codman. The tear is adequately exposed through this incision. He closes the longitudinal tear first. The remaining rent is sutured to raw bone by dividing the articular cartilage of the humeral head that lies beneath the V-shaped opening. Through drill holes in the greater tuberosity the sutures are tied, pulling the tendon into contact with the raw bone. The distal end of the acromion is excised and the wound is closed. The patient is permitted light use of the shoulder, but active elevation is limited for three weeks after operation.

Acromioclavicular Dislocation.—Acromioclavicular dislocations can in most instances be cured by the proper nonoperative treatment following the injury. In neglected cases and in those where the trapezoid and conoid ligaments are ruptured, it is often necessary to operate in order to obtain a stable articulation and restore strength to the injured shoulder. This may be done by using a strip of fascia lata for reconstruction of the ruptured ligaments, according to the method of Bunnell.

Campos has described an operation which seems very efficient and quite simple. A skin incision of 8 or 10 cm. is made, beginning slightly above the clavicle and running downward between the coracoid process and the acromion. The deltoid is dissected and a short lateral incision is made at right angles to its fibers, if necessary. The coraco-acromial ligament then appears as a tight band between the coracoid and the inferior surface of the acromion. A piece of gauze in a Kocher clamp is of great help in dissecting this area clean. With a thin knife, the posterior part of the coraco-acromial ligament is incised (Fig. 843), or both the posterior and the anterior parts are incised, as close as possible to the outer border of the acromion. The ligament is freed through its entire length from its inferior attachment, and a silk guide suture is placed at its freed superior extremity. A hole is drilled through the outer third of the clavicle in line with the coracoid at the point where the clavicle and the coracoid are closest together. The dislocation is reduced and the ligament is threaded through the hole from below upward (Fig. 844), fastened to the periosteum and locked with a chip of bone. The acromioclavicular capsule and the soft parts about the joint are carefully sutured The deltoid muscle and the skin are sutured and a plaster cast is applied which is worn for four weeks

Henry's operation is a reconstruction of the coracoclavicular ligament using a strip of fascia lata The coracoid process and the clavicle are exposed. The fascial strip is folded and passed around the coracoid process and over the clavicle subperiosteally. The ends of the fascia are overlapped and fixed with mattress sutures. A stainless steel wire loop is used to fix the acromioclavicular joint. After four weeks of immobilization exercises are started and at the end of ten weeks the wire loop is removed.

In acromioclavicular separation of more than one month's duration, or if the dislocation occurs in middle-aged individuals, the preferable operation is excision of the outer end of the clavicle. A minor degree of disability is present after this excision. Mumford and Gurd independently developed this plan of treating the dislocation. Through a small curved incision over the outer end of the clavicle, the distal end of the clavicle is exposed by subperiosteal dissection. With a bone-cutting forceps this segment is removed. The wound is closed, and a Velpeau bandage is worn for one week. In four weeks the patient is allowed complete motion.

## ARTHROPLASTY

Since the work of John B. Murphy, in this country, there has been increasing interest in the restoration of function to an ankylosed joint by arthroplasty. Willis Campbell, Baer, Henderson, and MacAusland in this country and Putti and Lexer in Europe have done much to standardize the technic of arthroplastic operations. The mold arthroplasty of Smith-Petersen is one of the most recent arthroplastic developments.

The biologic principle upon which arthroplasty rests is that following the interposition of soft tissue (usually fascia lata) between the remodeled bones of the new joint, this tissue undergoes changes which make it resemble normal intra-articular tissue. The interposed flap limits the granulation tissue growing out from the marrow spaces of the bone. In the flap itself a process of liquefaction and softening takes place which ends in the formation of a cavity with a sac not unlike a physiologic joint. Campbell had occasion to open a knee on which a successful arthroplasty had been performed one year previously. He found a definite joint space about one-half the capacity of the normal knee containing a very small amount of joint fluid. The articular surfaces were smooth, glistening, and regular, and covered with a dense layer of fibrous tissue resembling the transplanted fascia lata. A section was made through this, and what appeared to be a cartilaginous and superficial fibrous layer was found deep in it. Microscopic examination revealed dense fibrous tissue and areas of fibrocartilage. Apparently, functional use changes the interposed fascia into tissue similar to that covering the normal articular surface of bone.

Excision is not arthroplasty. It is wide resection of bone to induce a false joint. Arthroplasty is reestablishment of function. Arthroplasty should be limited to the joint ankylosed by trauma or by pyogenic infection and should never be attempted in a tuberculous joint. It should not be done until at least one year after all evidence of active infection has subsided. It may be attempted in atrophic arthritis after the process is quiescent. Practically, arthroplastic operations are limited to the elbow, the jaw, the hip, and the knee. If the patient follows a strenuous occupation, a stiff weight-bearing joint in good position is usually preferable to the joint obtained by arthroplasty. Careful selection of each case is necessary before performing an arthroplasty, and the proper aftertreatment is all important. The operations described below are those of Willis Campbell.

### Knee

Arthroplasty of the knee is done through a long medial incision somewhat like Krida's incision described above. The quadriceps tendon is freed from the femur

by dissection and the patella is separated from the femur by a chisel. If severely *contracted, the quadriceps tendon must be lengthened by the Z-plastic method* (Fig. 845); otherwise, it is retracted outward. The bony union between tibia and femur is divided by an osteotome (Fig. 846), and the knee is fully flexed. No attempt is made to restore the normal shape of the articular ends of tibia and femur. The lower extremity of the femur is made convex from above downward and from before backward, taking off only enough to reach cancellous bone. The upper extremity of the tibia is excised as little as possible to reach healthy, spongy bone.

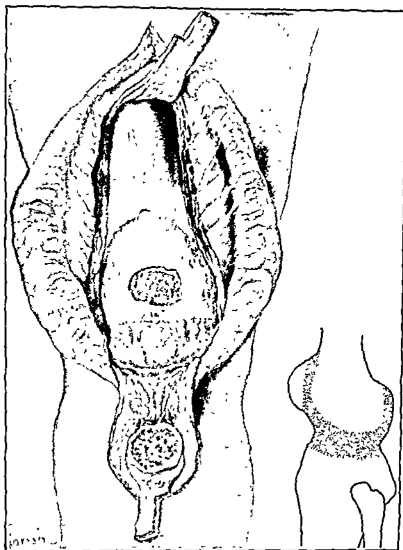


Fig 845. Fig. 846.

Fig. 845.—Arthroplasty of the knee The patella has been turned down and the quadriceps tendon lengthened. Dotted lines show the amount of bone to be removed through site of ankylosis

Fig 846—Arthroplasty of the knee. Lateral view showing amount of bone to be removed

It is then made slightly concave from before backward with a woodcarver's chisel, forming one large shallow cavity to receive the lone condyle of the femur (Fig 847) After this excision there must be at least 1.25 cm. of joint space when traction is made on the tibia. The raw surfaces are then approximated to make sure there is neither varus nor valgus.

Next the posterior surface of the patella is removed, leaving only a thin layer of bone, and its lateral margins are trimmed away for 0.5 cm. All bony surfaces are smoothed with a large rasp, and care is taken to remove all loose bony particles. Just below the patella and on the posterior surface of the patellar tendon will be

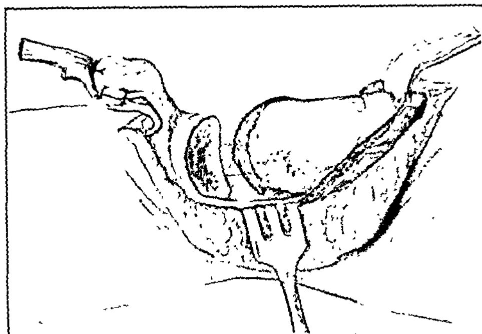


Fig. 847.—Arthroplasty of the knee. A single condyle is shaped for the femur and a single tuberosity of the tibia is formed.

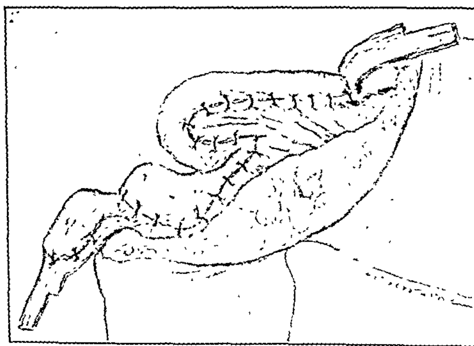


Fig 848—Arthroplasty of the knee. The new joint surfaces are completely covered with fascia lata.

found a mass of fat, and at times, remains of synovial membrane. This is severed at its junction with the tibia, dissected from below upward into a flap with a broad pedicle, and stitched to the tendinous margin about the patella, thus investing the patella's posterior surface.

From the opposite thigh a strip of fascia lata 10 to 12.5 cm. wide and 20 to 25 cm. long is obtained. With the outer surface of the fascia next to the bone, this membrane is placed over the lower 10 to 12.5 cm. of the anterior aspect of the femur, passes backward over the newly formed condyle, and is sutured to the posterior capsule of the joint as high as possible. It is then brought forward to cover the new articular surface of the tibia as far as the anterior aspect of the tibia. All free edges are stitched with a continuous suture of chromic catgut well over the margins of the joint (Fig. 848). The joint capsule, fascia and skin are sutured and the limb is placed in a Thomas splint.

## Hip

Arthroplasty of the hip is performed through the Smith-Petersen incision (Fig. 832). After exposure of the ankylosed joint (Fig. 849), with a large woodcarver's chisel, fusion is severed in a curve conforming to the head of the femur, beginning at a point about 0.5 cm. above the acetabulum. The hip is then dislocated by forcible adduction and external rotation, exposing the head and neck of the femur and the acetabulum. All contracted soft tissues must be divided, and often subcutaneous tenotomy of the adductors is necessary.

After this the articulating surfaces are remodeled (Fig. 850). The head of the femur is reshaped smaller than normal and all soft tissue, including cartilage, is removed from the acetabulum. When this has been done, manual traction on the limb should separate the articular surfaces 1.25 to 2.5 cm. The head of the femur is smoothed with a file or rasp and the acetabulum with a reamer. All particles of loose bone must be removed. A large sheet of fascia lata is removed from the same thigh and folded on itself so that the rougher superficial surface is transplanted against raw bone. One end is sutured to soft tissue at the upper margin of the acetabulum, then the fascia is cupped to invest the raw surface of the acetabulum, and the remaining portion is fastened completely around the head of the femur (Fig 851). It is held thus by No. 2 chromic catgut drawn through drill holes in the femoral neck and sutured through the fascia in purse-string fashion.

The head is then placed in the acetabulum with this double layer of fascia between the articulating bone surfaces. The capsule is sutured if possible, but an approximation of the deep muscles by a few interrupted sutures is all that is necessary. The wound is closed in the usual manner and a plaster spica is applied to the ankle, with adhesive traction strips under it and emerging for weight traction. This plaster is bivalved at the end of ten days and, if the incision is healed, passive motion is begun

In 1938, Smith-Petersen began the use of Vitallium molds shaped to cover the remodeled head of the femur in arthroplasty of the hip. He is the unquestioned authority in this special field of reconstructive surgery and the credit must be given him for his ingenious development of mold arthroplasty of the hip. His results in using mold arthroplasty for treatment of malum coxae senilis are generally very favorable. The majority of patients are able to lead active lives independent of the help of others. He feels that the results of mold arthroplasty done relatively early in the course of the disease of rheumatoid arthritis are more favorable than when done late in its course The operation may be indicated in aseptic necrosis, nonunion and absorption of the femoral neck as complications following hip fractures.

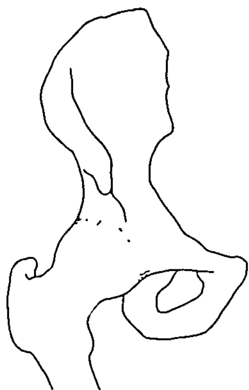


Fig. 849.

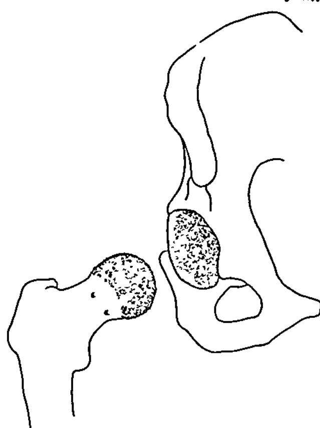


Fig. 850.

Fig. 849.—Arthroplasty of the hip Bony ankylosis of the joint.

Fig. 850.—Arthroplasty of the hip The new acetabulum and new head of the femur have been made In the latter, drill holes for the suturing of the fascia lata covering are shown

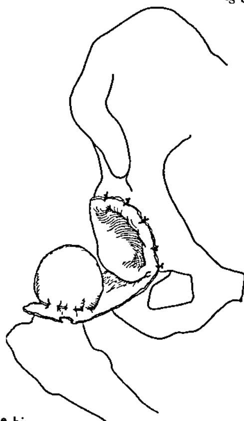


Fig 851.—Arthroplasty of the hip The acetabulum and the femoral head are shown invested with a continuous sheet of fascia lata.

During a ten-year period he used the Vitallium mold arthroplasty in 550 cases. The conditions treated included practically all to which the hip joint is subject.

The principle of mold arthroplasty is the interposition of a permanent inert barrier between two joint surfaces as nearly perfect as possible. The mold is to guide repair after a mechanical joint is created. For this the anterior acetabular wall and the anterior inferior iliac spine are osteotomized. This sacrifice of the inferior half of the inferior iliac spine and the anterior acetabular wall greatly facilitates the required hip joint dislocation. To minimize friction the mold must be loosely fitted, thus allowing the greatest possible range of motion between it and the adjacent, reshaped surfaces of the acetabulum and of the femoral head. To reshape these surfaces Smith-Petersen has designed the necessary gouges and reamers for remodeling the hip joint.

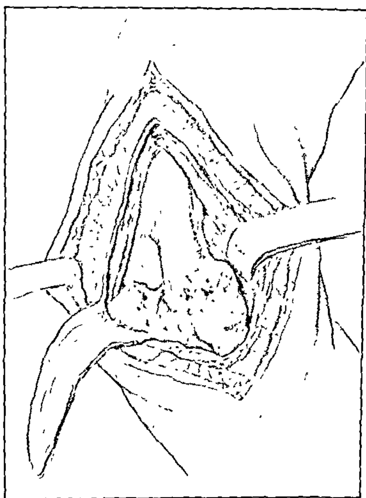


Fig. 852—Arthroplasty of the elbow. Showing method of lengthening the triceps tendon when elbow is ankylosed in extension.

The postoperative treatment of these cases of mold arthroplasty of the hip requires attention to detail from the time of wound closure until traction in a splint is applied. Abduction and neutral rotation of the extremity must be maintained. A Hodgen splint is used with traction of 5 to 7 pounds for four to six weeks. During this period a regular regimen of exercises both active and passive is instituted Roller skating exercises are used in the fifth week. At this time the patient is allowed to get out of bed. The walker, a stationary bicycle, and crutches are used in mobilizing the patient. After six to eight weeks the patient may leave the hospital, to be followed frequently for at least two years.

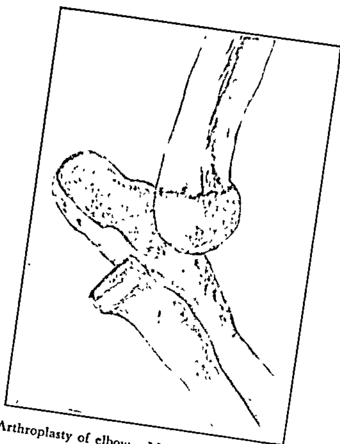


Fig. 853.—Arthroplasty of elbow. Modeling the new joint surfaces.



Fig 854 —Arthroplasty of elbow Fascia lata is used to line the new joint.

Elbow

Campbell employs an ingenious method for relief of ankylosis at the elbow. A long incision, extending from mid-humerus to 5 to 7.5 cm. below the elbow, is made just external to the midline of the posterior aspect of the arm and forearm. It is carried down to the deep fascia and dissected laterally about 2.5 cm., exposing the triceps aponeurosis. If the elbow is ankylosed in extension, a flap is made of this aponeurosis by a transverse cut above and division along its internal and external borders, leaving the flap attached to the olecranon (Fig. 852). This is to allow for lengthening of the shortened triceps tendon. A further incision in the midline passes through the muscular fibers of the triceps and the periosteum of the lower half of the humerus. The periosteum is then stripped from the lower third of the bone, exposing the head of the radius and the olecranon. Fusion between the three bones of the joint is severed with a curved chisel. The elbow is flexed and the radius and ulna are displaced medially.

The lower end of the humerus is shaped into one condyle convex from before backward. The superficial bone is excised from the sigmoid cavity with a curved chisel and the head of the radius is denuded to the level of the inferior portion of the sigmoid cavity. All surfaces are smoothed with a rasp (Fig. 853). A large strip of fascia lata is used to line the new joint. It is sutured completely over the lower extremity of the humerus and is then reflected to cover the sigmoid cavity. If there is fusion between the radius and ulna, sufficient bone is excised to permit free rotation of the radius. Fascia lata is placed between the radius and ulna, and the head of the radius is covered with fascia (Fig. 854). The articulation is then reduced and closure is done from below upward with the elbow flexed at right angles. The tongue of triceps aponeurosis is sutured at a lower point than its former attachment, thus permitting free play of the joint in flexion. If the ankylosis is in flexion, it is unnecessary to use this flap.

Arthroplasty is still in the experimental stage, and in most clinics the results are not nearly so good as we might wish. For the laborer, a fused, painless joint in good weight-bearing position is usually the better choice.

## ARTHRODESING AND STABILIZING OPERATIONS

Motion of impaired joints may be the exciting factor that produces pain and the factor that prevents healing in joint diseases. Motion that is excessive impairs function by instability. When joint motion is eliminated the joint no longer gives pain; rest is obtained and the body may be able to combat and overcome disease. The elimination of motion in a joint is called arthrodesis. In the unstable joint it gives stability. This word literally means a process by which the joint is tied together; it is the surgical fusion of apposed articulating surfaces. Braces to stabilize joints are not necessary and patients are enabled to use their extremities where beforehand it was impossible. The local joint function is restricted in order that the function of the organism as a whole may be possible.

The indications for arthrodesis may be altered by the newer drugs. Prior to the introduction of streptomycin the one hope for arrest and healing of tuberculous infections of joints was ankylosis. Whether antibiotic therapy will permit healing and at the same time preservation of the joint attacked by tuberculosis remains to be determined. Perhaps the indications for arthrodesing joints in rheumatoid arthritis will be changed by the successful use of ACTH and cortisone or the like.

At the present time arthrodesis is the treatment indicated in tuberculosis of joints and in joints that are impaired and disabled and painful from trauma, from osteoarthritis, and from instability.

At the time of stabilization, deformities, when present, are corrected in so far as possible. Deformities often follow muscle imbalance or instability, as a result of anterior poliomyelitis. The deformities of some cases of neglected clubfoot and of spastic paralysis call for arthrodesis.

A joint fusion may be carried out within the joint by removing the cartilage of the joint so that cancellous bony contact is obtained. One of the disadvantages of operating within an infected joint is the danger of reactivating or spreading infection. In children fusion is difficult because there is an abundance of cartilage in their joints, especially in patients younger than eight years of age. The possibility of failure to obtain bony union is endangered in the presence of an active destructive process within the joint. These disadvantages have led to the development of methods of arthrodesis without entering the joint. In tuberculous infections this method is to be chosen, for if the operation is on normal bone the probability of fusion is more favorable. It is often difficult to avoid opening the joint capsule in fusion operations so that a combination operation within and without the joint is usually employed in both tuberculous and nontuberculous joints.

### Foot and Ankle

Stabilization of the foot and ankle is a frequent and a satisfactory operation when properly done. The operation should not be undertaken in patients under ten years of age. The fusion makes possible walking without a brace. The contributions by Whitman, Hoke, Dunn, Steindler and Ryerson have been outstanding in the development of operations for arthrodesis of the ankle and foot.

Whitman, in 1901, reported his treatment for paralytic talipes calcaneus. His astragalectomy has proved useful in the treatment of the complications of fractures of the astragalus as malunion and aseptic necrosis. In fresh compound fractures of the astragalus, astragalectomy may be the indicated procedure. When the tuberculous infection is limited to the astragalus, the astragalectomy operation is indicated. This operation has been condemned by many surgeons. Among the disadvantages pointed out by them is the nearthrosis of the calcaneotibial joint, which may be painful, requiring a fusion operation. Thompson in his review of the records of the Hospital for Ruptured and Crippled has stressed the fact that astragalectomy should be performed only in patients between five and fifteen years of age with calcaneus and calcaneovalgus deformities. The indications and proper technic are of first importance. In many clinics tendon transference with a Hoke or Dunn stabilization of the foot has largely supplanted the Whitman astragalectomy.

The incision extends from behind the external malleolus forward below its tip and then in a curve over the dorsum of the foot to the head of the astragalus (Fig. 855). After dividing and reflecting the peroneal tendons, the external lateral ligament and the interosseous ligaments are divided. Working beneath the retracted extensor tendons, the surgeon dissects the astragalus, starting at the body and going forward to the neck and the head. The foot is then strongly inverted, which exposes the whole ankle joint, and all the ligaments attached to the astragalus are severed. This and the removal of the astragalus are facilitated by grasping it with lion-jawed bone forceps.

The new articulation at the ankle is then prepared. The soft tissues are stripped away from the inner surface of the scaphoid and a thin slab of bone is excised from the adjacent outer surfaces of the cuboid and os calcis. Next, the internal malleolus is dissected out, and the soft tissue is stripped back from it. This is to allow backward displacement of the foot on the leg. It is usually necessary to enlarge the mortise of the tibia and fibula, which is done by removing such cartilage as is necessary from the articular surfaces of the malleoli. The foot is displaced backward on the leg so that the malleolar mortise fits against the junction of the cuboid and os calcis on the outside and just behind the inner border of the scaphoid on the inside of the foot. The heel now projects backward and the anterior border of the tibia lies directly behind the level of Chopart's joint with the malleoli placed firmly in their new positions. This makes the foot and leg resemble an inverted T rather than an L. The peroneal tendons, if the muscles are active, are reunited or, better, are transplanted into the Achilles tendon. The soft tissues are sutured in layers and the skin is closed. A plaster cast is applied from above the slightly flexed knee to the toes, with the foot in plantar flexion and very slight valgus. Later, the plantar flexion is decreased when the cast is changed for removal of sutures. Immobilization is maintained for eight weeks and a brace is used for two months longer.

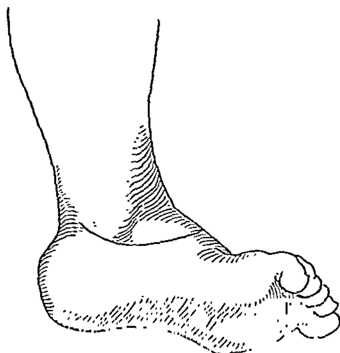


Fig 855.—Line of incision for Whitman's astragalectomy.

The greatest virtue in this operation is the amount of backward displacement of the foot on the leg. This gives a very stable foot and in cases of calcaneus and cavus aids greatly in the correction of the deformity. The operation has the disadvantage of shortening the extremity and sometimes results in some lateral instability. It is only fair to state that the latter is usually from error either in selection of cases or in technic.

Because of the loss of length from astragalectomy and because the most common deformity and instability of the foot are caused by rotation through the subastragalar joint, the present tendency is to stabilize the foot by some modification of

subastragaloid arthrodesis. Although by these operations the foot cannot be displaced backward as far as by Whitman's procedure, a fair amount of backward projection of the heel is obtained, the ankle joint is left intact, and the correction of deformity is effected distal to the astragalus.



Fig. 856.—Dotted areas show bone to be removed in a subastragaloid arthrodesis.

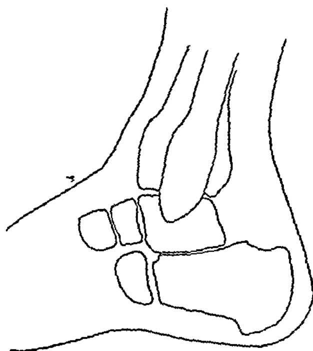


Fig. 857.—The os calcis is displaced backward on the astragalus after Hoke's operation.

An excellent operation of this type is Hoke's stabilizing operation. The incision is similar to that used in the astragalectomy, though usually not extending quite as far behind the external malleolus. The peroneal tendons are divided and the fatty tissue is excised from the subastragaloid fossa. The head, neck, and adjacent

portion of the body of the astragalus are stripped of soft tissue. The joint between the os calcis and astragalus is fully exposed by stripping the soft tissue away from the upper surface of the os calcis and from the lower surface of the astragalus. The head of the astragalus is separated from the scaphoid by dividing the astragalo-scaphoid ligament. Next, with a broad thin osteotome the adjacent portions of the lower surface of the astragalus and of the upper surface of the os calcis are removed throughout the entire width of the bones, shaping this removal as a wedge with its base outward or inward to correct varus or valgus deformity, respectively, as may be required. In calcaneocavus, more bone is removed posteriorly so as to improve the backward thrust of the heel Then with an osteotome the astragalus is divided at the base of the neck, and the head and neck are removed. The cartilage of the scaphoid and of the anterior surface of the os calcis is excised and the head of the astragalus is denuded of its cartilage. The cartilage is removed also from the posterior surface of the cuboid (Fig. 856). The posterior foot deformity is now corrected by setting the os calcis in line with the axis of the leg, and the whole foot is pushed backward on the astragalus, so that the weight-bearing center is placed further forward, with the os calcis tilted either upward or downward as required by the original deformity. The head of the astragalus is then reshaped so as to fit into the space between its body and the denuded scaphoid and is replaced (Fig. 857). Firm contact is obtained between the denuded bony surfaces. The incision is closed in layers. Plaster is applied from the toes to above the partly flexed knee with full correction of the deformity. Immobilization is maintained for twelve weeks. The operation is made simpler and shorter by the use of a tourniquet.

In some clinics the head of the astragalus is not replaced, but sufficient of the head and neck is removed to allow setting the foot back on the astragalus. Certainly, however, a more accurate fit between the scaphoid and astragalus is obtained by reimplanting the head.

This operation is excellent, and while it does not allow as much backward displacement of the foot as does the Whitman astragalectomy, the correction seems ample except in extreme calcaneus or cavus. Kite includes the calcaneocuboid joint in the Hoke stabilization. He advocates that the joints for fusion be "fish-scaled." He performs the operation in a slightly different order from that described above.

Recurrence of deformity of the foot after subastragalar arthrodesis has drawn attention to the necessity of transplantation of tendons accompanying the bone operation For example, if in the paralytic varus foot the anterior tibial muscle is active and the peroneals are paralyzed, the anterior tibial tendon must be transplanted to a mid-position on the dorsum of the foot. Otherwise, its unopposed pull will cause a gradual recurrence of the deformity. Many of the disappointing final results after subastragalar arthrodesis are due to failure to transplant the tendon of a deforming muscle to a point where its action will not tend to cause deformity Peabody has shown that recurrence of deformity does not take place if the deformity is static. Dynamic deformities require tendon transference.

In cases of "foot-drop" deformity, an operation to establish a bony block posteriorly at the ankle stabilizes the foot to prevent the vicious planter flexion. When a subastragaloid arthrodesis is done at the same time, Campbell's bone block operation may be used. If the only deformity to be corrected is foot drop, then Gill's procedure is simpler and just as effective A skin incision is made parallel to the Achil-

les tendon, which is exposed and divided Z-fashion. An incision is then made longitudinally through the underlying fat, which is scraped to both sides to expose the posterior aspect of the ankle joint and the top of the os calcis. The ankle joint is opened.

The foot is dorsiflexed to the limit of motion. This brings the posterior portion of the upper articular surface of the astragalus into view. With a broad thin osteotome the cartilage, with a thin portion of bone of the astragalus, is lifted upward from behind until it comes into contact with the posterior lip of the tibia. The angle of the wedgelike space thus formed lies well forward beneath the cartilage and in front of the posterior lip of the tibia. With care, this plate of cartilage and bone is bent upward at its anterior aspect without breaking. A wedge-shaped piece of bone is then removed from the upper aspect of the os calcis and is driven firmly into the space beneath the superior portion of the astragalus (Fig. 858). The Achilles tendon is lengthened as necessary and sutured. The wound is closed, and the foot is dressed in plaster in slight dorsiflexion for three months.

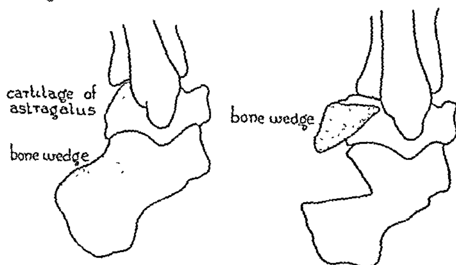



Fig. 858.—Gill's operation for drop foot In the left is the line of incomplete osteotomy just proximal to the posterior border of the astragalus. On the right is the thin portion of bone and cartilage of the astragalus held in place against the posterior lip of the tibia by a wedge-shaped piece of bone removed from the os calcis.

In 1927, Lambrinudi reported a procedure for stabilization and correction of drop foot. In this method the astragalus remains locked in the ankle mortise in equinus. The deformity is corrected in the subastragalar joint. If lateral instability of the foot is present, a plantar arthrodesis is to be preferred over the Lambrinudi method.

Fusion of the ankle joint for tuberculosis is usually unsatisfactory. The use of streptomycin has made the outlook much brighter In many cases the tuberculous process has already spread to other bones of the tarsus, and also there is difficulty in obtaining bony ankylosis of the joint even when the disease is confined to it. Campbell proposes an extra-articular fusion by turning down a long osteoperiosteal graft from the anterior surface of the tibia to the denuded surface of the neck of the astragalus and by placing posteriorly between the tibia and os calcis a graft obtained from the posterosuperior surface of the os calcis.

**Fusion of the Ankle.**—Although often unsatisfactory in tuberculosis of the ankle, arthrodesis of the ankle joint with the foot in slight equinus is sometimes indicated in the painful joint following arthritis or malunited fractures about the ankle.

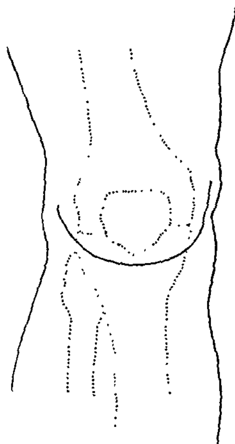


Fig. 859.



Fig 860.

Fig. 859.—Hibbs' knee fusion. Incision.

Fig. 860.—Hibbs' knee fusion. Cartilage is removed from femur, tibia, and patella, down to bleeding bone and groove in femur and tibia, for inset of patella.



Fig 861.—Hibbs' knee fusion. The completed operation

The operation as described by Willis Campbell and Speed through the anterior approach is advised. It gives a solid fusion and is not particularly difficult to perform.

The joint is exposed by an incision over the anterior surface of the ankle, just lateral to the extensor tendons. The anterior surface of the joint is thoroughly exposed, giving a clear view of both malleoli. The astragalus and the tibia are denuded of articular cartilage, and sufficient bone is removed to provide an unobstructed view of the entire ankle joint. The articular cartilage is next removed from the internal and the external malleoli. The astragalus is brought into position, correcting any posterior or lateral deformity which may be present. A graft, 2.5 cm. by 5 cm., including the entire thickness of the cortex, is removed from the anterior cortex of the tibia. This graft is dropped down across the joint and is countersunk into the neck of the astragalus. Metal screws inserted through the graft into the tibia and astragalus maintain the position and prevent displacement of the graft. The leg is immobilized in a plaster cast, with the foot in the position of slight equinus without inversion or eversion. Slight equinus gives a better walking position for the foot. Immobilization is continued until the x-rays show solid bony ankylosis.

**Knee**

Arthrodesis at the knee is most often indicated in tuberculosis of that joint. It is also used in certain cases of arthritis and postraumatic lesions of the knee, where the elimination of pain, with a stable, weight-bearing joint, is the desired result. Here the choice is between arthroplasty and arthrodesis. In the "flail" knee of anterior poliomyelitis, arthrodesis is sometimes advisable. In this case, however, it is well to give the patient a choice between a permanently stiff knee and wearing a brace.

Hibbs' operation of "knee fusion" is the method of choice where it can be used. A U-shaped incision is made below the patella (Fig. 859), dividing the patellar ligament and opening the capsule The entire flap, including the patella, is turned upward. The patella is mobilized by dissecting around its circumference, leaving it attached only by a small central pedicle. All the soft tissue structures within the joint are then carefully excised, except that the crucial ligaments are often left if intact. If the synovium is involved by disease, a synovectomy as complete as possible is carried out. The articular surfaces of the patella, femur, and tibia are carefully denuded of all cartilage only, leaving raw bony surfaces everywhere in the joint. Then a bed for the patella graft is prepared. If the patella is involved in the destructive process, it is excised. A transverse cut is made into the lower end of the femur and a groove the width of the upper end of the patella is chiseled out with overhanging anterior lip A similar groove facing upward is made in the upper end of the tibia large enough to receive the lower end of the patella (Fig 860). These grooves must be made deep enough to receive the patella so that when the knee is extended the raw bony surfaces of condyles and tuberosities are in contact. If it be necessary to correct lateral deformity at the knee, the requisite amount of bone is removed from the medial or lateral portion of the joint as may be required. With the knee flexed, the upper end of the patella is inserted into the groove in the femur. The lower end of the patella is next inserted under the overhanging anterior lip of the tibial groove, and, as the knee is extended, the patella is firmly wedged into place in its bed, lying across the joint and held firmly in the tibial and femoral grooves by the overhanging ledges of bone (Fig. 861). The patellar tendon is su-

tured and the incision is closed in layers. In some cases it is impossible to place the patella in its bed without completely freeing it from its attachments. Here it is used as a free graft with the same success. A plaster spica is applied and the knee is kept immobilized until x-ray evidence of bony fusion is present. The time for such fusion to occur varies from three months to a much longer period.

Hibbs' method of knee fusion is particularly valuable in growing children. This operation, when correctly done, does not endanger the epiphyses at the knee and thus will not interfere with growth. The knee, in children, is usually fixed in extension, as this causes less stress on the upper tibial epiphysis and flexion deformity tends to recur.

In adults, an operation to ankylose the knee joint can be done more quickly by sawing off the adjacent articular ends of the femur and of the tibia in such a manner that they come into close bony contact. After this some surgeons prefer to maintain snugger fixation and contact for the first few weeks by the use of nails holding the two bones together or by a bone peg driven into the cancellous surface of each bone. The Küntscher intramedullary nail is used for fixation. A Smith-Petersen nail has been used in nontuberculous knees by Bosworth.

The external Haynes apparatus as used by Johnson is an excellent method to maintain position and bony contact. This apparatus is so constructed as to allow for change of position and for impaction. The patient does not have to wear a long leg cast with the Haynes fixation. Key has described the use of pins and turnbuckles. Firm contact is maintained by tightening the turnbuckle.

Where bony ankylosis of the knee has occurred in flexion, it is necessary to remove a wedge of bone with the base anterior through the joint line in order to correct the deformity. Care must be taken here not to stretch the posterior soft structures too much, because of the risk of injury to vessels and nerves.

## Hip

Stabilization of the hip by the shelf operation has been described above. The indications for arthrodesis of the hip are similar to those for stabilizing other joints. Extra-articular fusion is the one of choice, especially in treating tuberculosis of the hip. In adults nontuberculous lesions of the hip may be fused by the Watson-Jones method of using a Smith-Petersen nail for internal fixation.

In 1926, Hibbs reported a procedure which is an intra-articular and extra-articular operation. The superior aspect of the capsule is opened. The head of the femur and the acetabulum are not disturbed and the principle of a pedicle graft is used. The anterior two-thirds of the trochanter is used as the graft, with the periosteal attachment left at the upper part of the trochanter.

An incision is made beginning above and behind the anterior superior spine and extending straight down over the greater trochanter for 7.5 cm on the shaft of the femur (Fig. 862). The deep fascia is split, the tensor fasciae femoris is retracted medially (Fig. 863), and the fibers of the gluteus medius and minimus are bluntly separated, exposing the joint capsule. The periosteum of the femur is cut along the line of the base of the trochanter and elevated medially. With a chisel the anterior three-fourths of the trochanter with at least 5 cm. of femoral cortex is cut off from the bone, leaving periosteum and muscular attachments intact. The capsule is then split and the cortex is removed from the superior aspect of the neck of the femur. A mass of the ilium, including the upper acetabular rim, is elevated with an osteo-

tome without breaking it loose above or disturbing the periosteal and muscular attachments. The graft of trochanter and shaft cortex is now rotated so as to fit the lower or cortical end under the elevated iliac mass. The trochanteric end is snugly wedged against the tip of the remaining fourth of the trochanter with the base of the trochanter making firm contact with the cancellous bone of the femoral neck (Figs. 864 and 865). The periosteum of the transposed graft is sutured to the periosteum of the ilium above and to that of the femur below. When the thigh is abducted 15 degrees and flexed slightly, the graft is wedged firmly in place between the ilium and the remaining tip of the trochanter.

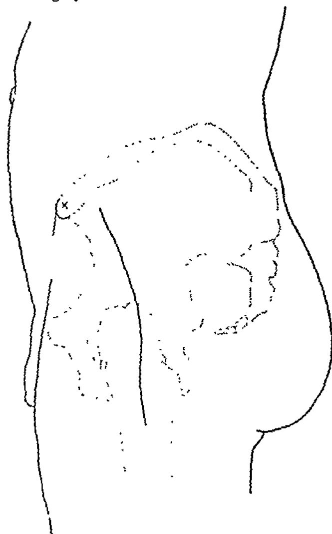


Fig. 862.—Incision for Hibbs' fusion of the hip

Wilson exposes the capsule of the hip through a liberal anterolateral incision (Fig. 832) The muscular attachments to the great trochanter are freed with a blunt dissector The epiphysis of the trochanter, if not ossified, is displaced, because, if cartilaginous, it endangers the nutrition of the bone flap. The shaft of the femur should be exposed for about 6 cm., which aids in the preparation of the trochanteric cleft. The joint capsule is split on its superior aspect, the anterior superior attachment to the ilium is freed and well retracted. The great trochanter is next split for a distance of 5 cm. in the the longitudinal axis of the femur. A very thin osteotome is used to reflect a fan-shaped section of the outer cortex of the ilium, the base of the fan just above the margin of the acetabulum remaining attached. By

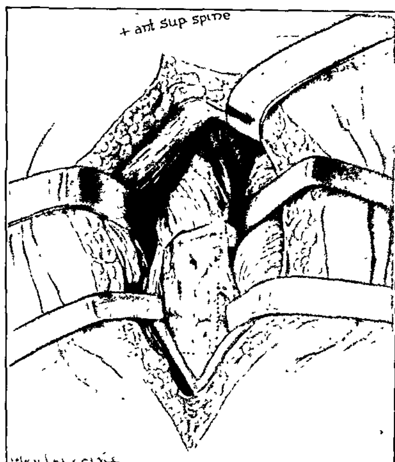



Fig. 863 —Incision to outline the trochanteric graft.

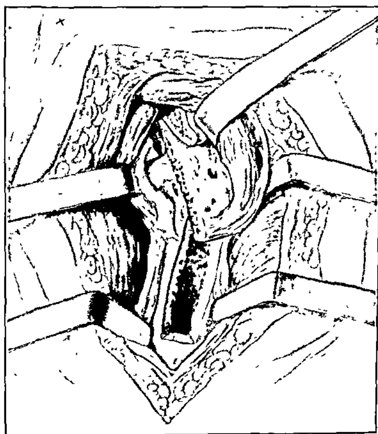


Fig 864.—Hibbs' fusion of hip. The trochanteric graft, with the muscles attached, has been rotated so that the cortical portion from the shaft is sunk into the slot in the ilium.

exercising a little caution the flap is turned into the trochanteric cleft by bending the pedicle (Figs. 866 and 867). A greenstick fracture of the flap may result, but the blood supply is not necessarily interrupted.

Since the periosteum of the ilium is stripped down with the gluteal muscles when the joint is exposed, replacement of the muscle flap brings the periosteum and fresh bone surfaces in contact. A solid pyramidal section of bone is the result, the neck of the femur forming the base of the pyramid.



Fig. 865—Skeletal drawing to show position of the trochanteric graft at the conclusion of Hibbs' fusion of the hip.

In either of these operations, after closure of the wound the patient is placed in a previously prepared, well-dried and well-warmed, bivalved, long, double spica cast The hip is protected until there is x-ray evidence of strong bony fusion.

Brittain, in 1941, described an ischiofemoral arthrodesis of the hip that is extra-articular. The subtrochanteric area is osteotomized and a broad tibial bone graft is placed through the osteotomy into a cleft in the ischium. One of the advantages of this procedure in treatment of tuberculosis of the hip is the fact that the disease progress does not interfere with the arthrodesis if the ischium is not involved. In 1932, Trumble described an extra-articular fusion in which a graft is placed

from the femur to a cleft in the ischial tuberosity. The operation is under direct vision by exposing the sciatic nerve and the grafted sites by means of a posterior incision. This seems to be an advantage over the Brittain procedure.

In 1934, Watson-Jones introduced the use of the Smith-Petersen triflanged nail for internal fixation. Burns used a large type Smith-Petersen nail driving it into the ilium above the trochanter. The intra-articular fusion of the hip is performed. Unless some complication arises from inserting the nail, a cast is not used. In ten days to two weeks the patient is permitted to be up. This procedure is especially applicable in old patients with degenerative osteoarthritis of the hip.

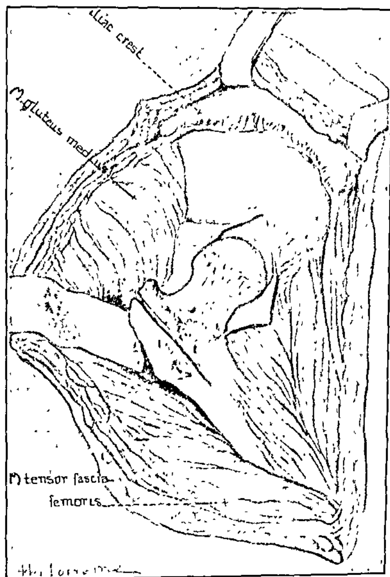



Fig 866.—Wilson's arthrodesis of the hip. The capsule has been opened, the ilium exposed, and greater trochanter and shaft of femur have been split.

The upper extremity does not call for arthrodesing operations as frequently as the lower. Motion is the prime function in the upper extremity, and a movable, though weak, joint may be more desirable than a motionless, stable one. Again, tuberculosis is much less frequent than in weight-bearing joints. However, arthrodesis is at times indicated in the wrist and in the shoulder. It is rarely indicated at the elbow, unless for tuberculosis, and is difficult to attain.

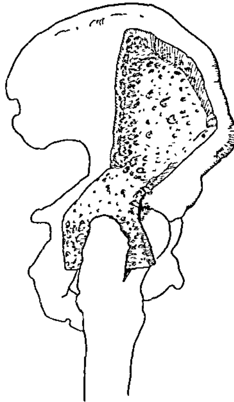


Fig. 867.—Wilson's arthrodesis of the hip. The iliac flap has been inserted into the trochanteric cleft

## Shoulder

The chief indications for arthrodesis of the shoulder are tuberculosis and residual paralysis following anterior poliomyelitis. In anterior poliomyelitis the muscles which move the arm on the scapula have been left paralyzed, while the elevators and rotators of the scapula itself must be active. Arthrodesis is contraindicated when the bones and forearm muscles are extremely paralyzed and when the shoulder muscles are so involved as to make impossible elevation of the shoulder. By fixing the arm to the scapula in the position of election, valuable movements of the extremity may be obtained by using the scapular muscles

Gill has described an excellent operation for arthrodesis of the shoulder. A horseshoe incision is made about the acromion 1.25 cm. below its border. At the point of the shoulder over the greater tuberosity of the humerus a vertical incision is carried downward from the first incision for about 5 cm. (Fig 868). This divides the skin over the arm into anterior and posterior flaps. All three skin flaps are then dissected away freely from the underlying fascia. A deep incision is made about the tip and lateral edges of the acromion, separating the atrophied deltoid and the deltoid fascia from the attachment to the acromion. The upper portion of the fascia is cut away for 2.5 cm., revealing the capsule of the shoulder joint. The capsule is opened and is freely excised over the upper part of the joint from its attachment to the upper edge of the glenoid to within 2.5 cm. of its attachment to the humerus. The extracapsular tissue beneath the acromion is excised with the capsule. The long head of the biceps must be identified and spared in making the excision If accidentally cut, it is thrust into the shoulder joint to become imbedded in the bone when the joint becomes ankylosed. From 1.25 to 2 5 cm. of capsule is left attached to the humerus above the greater and lesser tuberosities.

*from the femur to a cleft in the ischial* tuberosity. The operation is under direct vision by exposing the sciatic nerve and the grafted sites by means of a posterior incision. This seems to be an advantage over the Brittain procedure.

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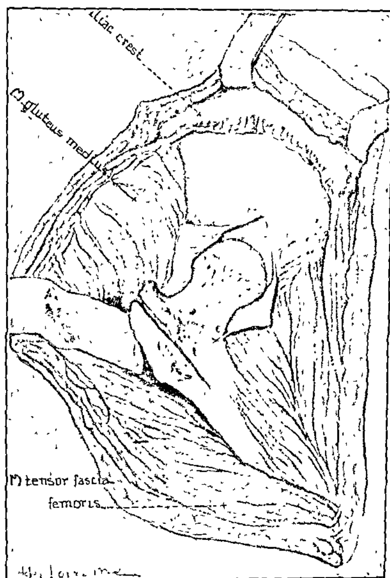



Fig. 866.—Wilson's arthrodesis of the hip The capsule has been opened, the ilium exposed, and greater trochanter and shaft of femur have been split.

The upper extremity does not call for arthrodesing operations as frequently as the lower Motion is the prime function in the upper extremity, and a movable, though weak, joint may be more desirable than a motionless, stable one. Again, tuberculosis is much less *frequent than in weight-bearing* joints. However, arthrodesis is at times indicated in the wrist and in the shoulder. It is rarely indicated at the elbow, unless for tuberculosis, and is difficult to attain.

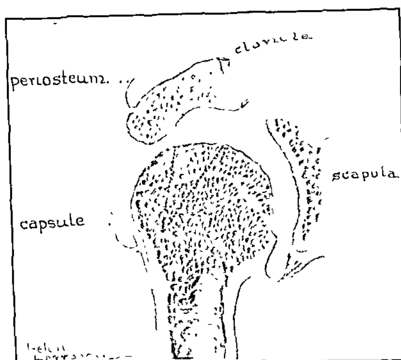



Fig. 869.—Gill's arthrodesis of the shoulder. Outline of wedge to be removed from denuded head of humerus.

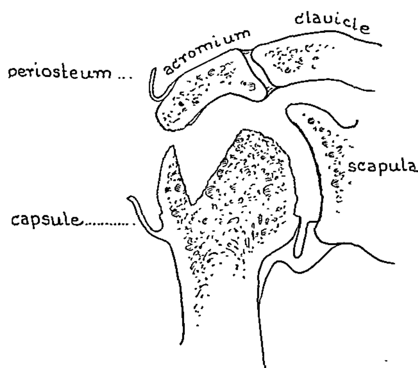



Fig. 870.—Gill's arthrodesis of the shoulder. The cleft has been made in the head of humerus for reception of the denuded acromion.

The inferior surface of the acromion is then denuded of periosteum with a sharp thin osteotome. With the same instrument the periosteum is elevated from the superior surface of the acromion and left attached at its proximal aspect, thus leaving a denuded acromion. The articular cartilage and the glenoid ligament are removed from the glenoid process, and the cartilage with a portion of bone is removed from the head of the humerus (Fig. 869).

With an osteotome the head of the humerus is split longitudinally, so that a thin outer and anterior portion may be reflected slightly outward. A small wedge of bone with the base upward is removed from the remaining part of the head (Fig. 870). A cleft is thus made in the humerus beneath the tip of the acromion The capsule remains attached to the outer and anterior portion. When the arm is abducted, the acromion fits into this cleft and becomes buried in it to the depth of 1.25 to 2.5 cm. (Fig. 871). It is to allow the acromion to sink into this cleft that a portion of the head of the humerus is removed with the articular cartilage.

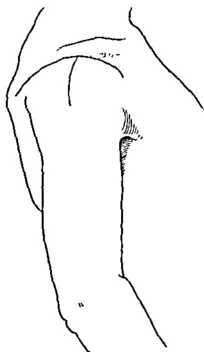


Fig 868.—Gill's arthrodesis of the shoulder. Incision.

The capsule attached to the humerus is sutured to the periosteum and its overlying fascia, which have been reflected upward from the acromion. These are both strong and heavy tissues, and they are overlapped as they are sutured. The position of the acromion is thus maintained firmly buried in the humerus. It is the integrity of these structures which prevents rotation of the scapula after the operation has been completed and the cast has been applied, and which maintains any degree of abduction of the humerus in its relation to the scapula that the surgeon may elect The degree of abduction may be regulated by the excision of the wedge of bone described above. The broader the base of the wedge, the less the abduction secured. Furthermore, if the capsule and periosteum are well overlapped and sutured firmly, greater abduction is maintained than if they are loosely sutured.

Gill believes that the proper angle of abduction is 45 degrees. Other surgeons prefer 60 degrees of abduction. In any case, after the wound is closed a cast is applied with the arm abducted and slightly forward so that the hand is near the

from the upper arm to the tips of the fingers. At the end of three weeks a short arm cast is applied and kept on until bony union takes place. Ten weeks ordinarily are required for this fixation.

## Spine

Arthrodesing operations on the spine are in a somewhat different category from arthrodesis of other joints. If the operation is done for vertebral tuberculosis, as is most frequent, it is rare that diseased bone is encountered. The body of the vertebra is the seat of the disease unless the tuberculosis has progressed so far that pedicles and laminae are involved. The operative procedure is confined to the neural

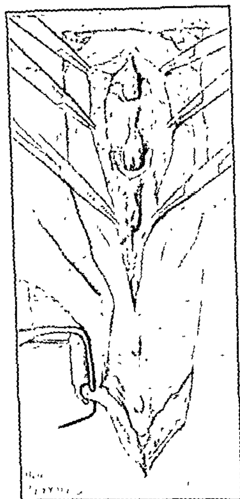


Fig 872

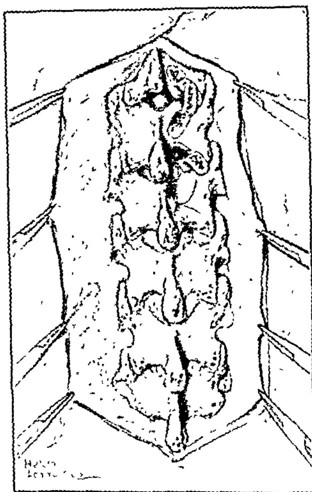


Fig. 873.

Fig 872 —Hibbs' spine fusion. Subperiosteal exposure of spinous processes and of laminae

Fig 873 —Hibbs' spine fusion. The laminae have been exposed out to the lateral articulations. After the latter are curetted, a substantial piece of bone is turned down and another piece turned up from each lamina in order to bridge the space between adjacent laminae.

arches and the spinous processes The object of the operation is to splint the spine by converting the posterior portion of the section operated upon into a solid sheet of bone In addition to Pott's disease, arthrodesis of the spine is used in the treatment of scoliosis, of spondylolisthesis, and sometimes in old, neglected fractures of the vertebrae. One of its most frequent uses is in the painful back due to instability and after removal of a ruptured intervertebral disc, where instability or bone defects or anomalies are present.

mouth. The plaster includes the entire arm and the hand and the body down to the pelvis, so that the shoulder is firmly fixed. The cast is not removed for twelve to fourteen weeks, when fusion is usually firm.

Watson-Jones does an extra-articular fusion of the shoulder by exposing the upper humerus, the acromion and clavicle and spine of the scapula. The acromion process and clavicle are wedged into a bone flap on the humerus by fracturing the scapular spine and the clavicle. A shoulder spica cast is used.

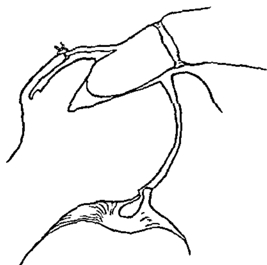


Fig. 871.—Gill's arthrodesis of the shoulder. The acromion has been sunk into the humeral cleft. The capsule and periosteum, with its overlying fascia, have been sutured together.

## Wrist

Arthrodesis of the wrist is indicated in certain cases of tuberculosis, in cases of flail wrist from residual paralysis of poliomyelitis, in some cases of arthritis of the wrist joint, in some comminuted fractures of the distal end of the radius, in paralytic wrist drop, and sometimes in spastic paralysis.

The procedure described by Abbott is efficient. As in the majority of operations that are used for wrist fusion a graft is used. He does not fuse the carpometacarpal joints, and the strength of grasp in the hand and the metacarpal arch of the hand are thus maintained. Colonna has used with success a longitudinally split rib for the graft.

Abbott makes a curvilinear incision over the dorsum of the wrist. Over Lister's tubercle the dorsalcarpal ligament and the periosteum are incised. By subperiosteal dissection the radius is exposed, the tendons are retracted, and the radiocarpal ligament is incised, exposing the joints beneath With a gouge the radiocarpal joint cartilage is removed. The capsule with a thin layer of cortex is raised from the scaphoid, semilunar, and capitate bones, exposing the carpal joints. A bone flap is turned upward from the radius. Because of the epiphyseal line in children, a horizontal cut is made in the radial articular surface for reception of the graft. The cartilage between the exposed carpal joints is excised and cancellous grafts from the ilium are placed over the dorsum of the wrist so that their ends are tucked under the raised flaps The grafts are stabilized by dorsiflexion of the wrist. The incision is closed with interrupted catgut sutures, and a cast is applied with the elbow at right angles and the wrist at 165 to 170 degrees of extension The cast extends

gauze packs. The periosteum of each tip and the interspinous ligament between, including each vertebra to be fused, is split in turn and the periosteum is freed from the bone and treated as described.

Beginning at the upper end again, with a dull periosteal elevator for children, and a sharp one for adults, the operator separates the periosteum and carries the subperiosteal dissection farther and farther forward upon each vertebra, in turn, until the spinous processes, the posterior surfaces of the laminae, and the bases of the transverse processes are bared, thereby exposing the ligamentum subflavum attached to the margins of the laminae and the articulations of the lateral processes. As each neural arch is bared, a small gauze pack is inserted before going on to the next vertebra.

Beginning above with a small curette, the surgeon destroys the lateral articulation and removes the periosteum and ligament from the adjacent edges of the laminae and the bases of the spinous processes. This is done with each vertebra over the entire field, packs being inserted as the operation proceeds.

Again starting at the upper end, with a bone gouge, a substantial piece of bone is elevated from the adjacent edges of each lamina, of half its thickness and width. The free end of the piece from above is turned down to make contact with the lamina below, and the free end of the piece from below is turned up to make contact with the lamina above (Fig. 873). This is done in turn with each vertebra to be fused, except the uppermost and the lowest ones, in which the piece is turned only down and up, respectively. Gauze packs are inserted as before.

Each spinous process is then partially divided with bone froceps and broken down, forcing the tip to come into contact with the bare bone of the vertebra below. The spinous process of the last vertebra fused is turned up to make contact with the one next above (Fig. 874).

Additional bone, when indicated, is usually obtained from the bone bank, or tibia, or from the ilium at the posterior superior spine. This supplementary bone is used to bridge over the interlaminal spaces. The extra bone is chiefly indicated when a spina bifida exists and when a ruptured nucleus pulposus has been removed. Iliac strips may be placed along the base of the spinous processes at the site of the removed nucleus. By turning down a flap along the spinous processes the grafts can be firmly imbedded so that they are stable.

The periosteum and ligament, which have been split and pushed to either side and lie in practically an unbroken sheet, are brought together in the midline and are united with interrupted sutures of chromic catgut (Fig. 874). The subcutaneous tissue is closed with continuous catgut and the skin with silk. Sterile dressings and a bivalved body cast are applied. The shells are prepared prior to operation. The indicated lesion determines the length of bed rest postoperatively.

With careful subperiosteal dissection and the use of many small gauze packs, hemorrhage should not obscure the field of operation.

*Albee's Operation.*—Albee uses a bone graft taken from the tibia and implanted in a bed made in the spinous processes. Through a curved incision the spinous processes are exposed, the supraspinous and interspinous ligaments are split longitudinally, and the spinous processes are split in half nearly down to the neural arches. One-half of each spinous process is fractured completely at its base and displaced laterally. The graft bed thus prepared presents a median longitudinal

Hibbs and Albee evolved operations for stabilization of the spine about the same time, and both operations are still largely used. Hibbs' spine fusion operation is more often used, as it seems more thorough, affords a wider bony sheet against strain, and requires only one incision. On the other hand, it usually takes more time to perform. Both operations, properly done, effect strong, bony fusion. In either, at least two vertebrae above and two below the affected area must be included in the operation. A number of operations have evolved from combining these two operations and using grafts of different types.

Before making an incision, marker films should be made so as to identify accurately the level of spinous processes.

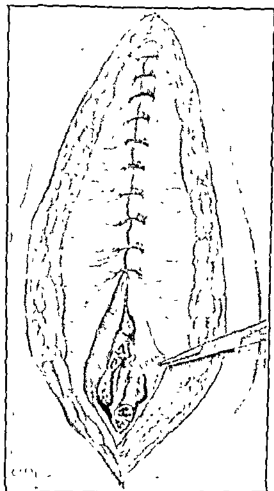


Fig 874.—Hibbs' spine fusion. The upper part of the drawing shows the closure of the periosteum and ligament with interrupted sutures In the lower angle of the wound are shown the spinous processes of the last two vertebrae to be fused, placed across the interlaminal space on each side of the midline. Ideally, they should be turned to the side like a greenstick fracture; but actually they are often completely fractured as shown

**Hibbs' Operation.**—An incision is made through the skin and subcutaneous tissue from above downward over the spinous processes of the segment to be fused, exposing the tips. The periosteum over the tips of the first two spinous processes above and the interspinous ligament between them is split with a knife (Fig. 872). The incision must be in the midline to avoid bleeding. With a periosteal elevator, the periosteum is pushed to each side for about one-half the length of the spinous process, and small gauze packs are inserted to prevent oozing. The control of bleeding is very essential and requires subperiosteal dissection with the use of many small

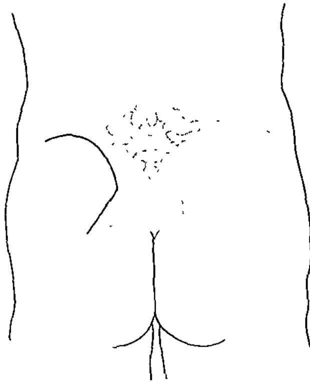


Fig 876.—Campbell's operation for extra-articular fusion of the sacroiliac joint. Line of incision along posterior crest of ilium

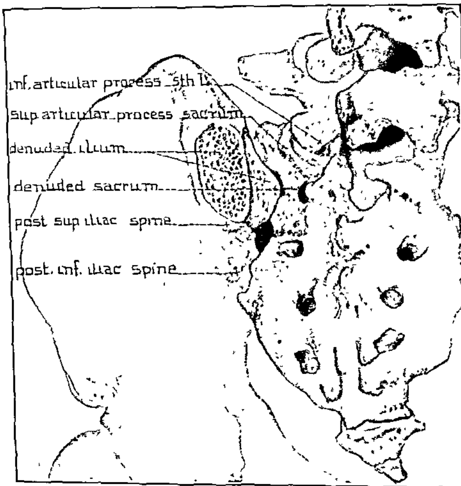



Fig. 877.—Campbell's operation for extra-articular fusion of the sacroiliac joint. The adjacent portions of iliac crest and sacrum are denuded, and a portion of the crest has been removed for a graft.

gutter into which a graft of sufficient length, which has been removed from the tibia by a motor saw, is placed The supraspinal ligament, muscles, and fascia are sutured over the graft.

In 1940, King used metal screws across the articular facets after removal of their cartilage. The value of this addition in the way of internal fixation has been verified by Toumey, Howorth and Baker.

## Sacroiliac Arthrodesis

The two indications for sacroiliac arthrodesis are traumatic separation with a persistent painful joint and tuberculosis of the joint. After a period of eighteen months or two years following separation, a spontaneous fusion usually takes place, making surgery unnecessary.

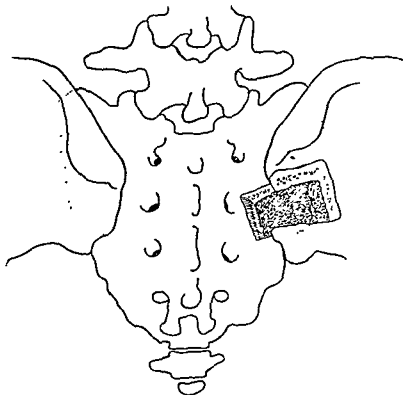


Fig 875 —Smith-Petersen operation for sacroiliac fusion

**Smith-Petersen Operation.**—The Smith-Petersen operation is an excellent means of fusing this joint. A curved incision is made from the posterior superior spine along the crest of the ilium two-thirds of the distance to the anterior superior spine. The incision is carried into the muscles and the periosteum is stripped off from the outer flare of the ilium From the posterior superior spine, the incision is then continued downward in the direction of the fibers of the gluteus maximus for a distance of 7.5 or 10 cm. The gluteal fascia is divided and the muscle is bluntly separated until the posteror portion of the outer flare of the ilium is encountered. The superior gluteal nerve and artery swing over the horizontal border of the incisura ischiatica into the mass of the gluteus muscle. By keeping away from this horizontal border, they can be avoided After the muscle periosteal flap is reflected backward, the sacroiliac articulation is located by marking a point about 2.5 cm above the border of the sciatic notch and 2.5 cm. forward from the posterior inferior spine. From here a window of rectangular shape, 2.5 by 3.75 cm in size, is cut out, the

# CHAPTER 67

# PYOGENIC OSTEOMYELITIS; BURSITIS; INGROWING NAIL; BUNIONS AND HALLUX VALGUS; HAMMERTOE

M. Josiah Hoover, Jr.

## OSTEOMYELITIS

### General Considerations

Acute hematogenous osteomyelitis is an inflammation of bone secondary to a blood stream infection. The infection may be acute, subacute, chronic, or residual. The surgical procedures vary, as well as the indications for surgery, according to the stage of the disease. Acute hematogenous osteomyelitis is caused by the hemolytic *Staphylococcus aureus* in the large majority of cases. The streptococcus is the next most common causative organism. Here, only osteomyelitis caused by pyogenic organisms is considered. Males are affected twice as frequently as females, as boys are subject more frequently to trauma than are girls. Acute hematogenous osteomyelitis is principally a bone infection of childhood and adolescence. The active growth period, the presence of epiphyseal cartilage, and the hairpin capillary loops are factors in its localization. The capillary loops and the medullary spaces of the epiphyses permit the bacteria to lodge in the metaphyseal region because of the slowed circulation at this point. In adults it is infrequently seen after the epiphyses have closed, because this anatomic relationship ceases to exist. A focus of infection as a furunculosis or tonsillitis may be the route by which the organisms enter the blood stream. The elective tonsillectomy and the use of the antibiotics, as penicillin and others, have been two important factors in the marked decrease in the occurrence of this bone infection.

Acute osteomyelitis may be the result of direct extension of the infection in adjacent tissues. The bone felon, the phalanx being involved secondarily to infection in the finger pulp, is an example. In compound fractures osteomyelitis may occur from direct implantation of the organisms.

The metaphysis near the epiphyseal line is agreed by most to be the site of the primary bone infection. A bone abscess develops as the bacteria multiply, since the bone plays no part in walling off the infection, and the abscess gradually increases in size. Because the cartilaginous plate blocks its spread, the infection passes through the cancellous bone to the subcortical zone and through the cortex to the subperiosteal area. An abscess is formed at this point, stripping up the periosteum. The infection may reach the medullary cavity retrogradely by way of the Haversian canals (Fig. 878). The infection beginning in the metaphysis may extend the entire

lower side paralleling the lower edge of the os ilii (Fig. 875). In adults it is necessary to penetrate into the bone for a depth of about 2.5 cm. When this depth is reached, the surgeon comes upon the sacroiliac articulation and the rectangular piece of bone may be lifted out. The deep surface of this block of bone has upon it the articular cartilage of the iliac portion of the sacroiliac joint, and, when the block is lifted up, the articular surface of the sacrum is seen deep in the field. The cartilage is removed from the sacral surface of the articulation until only bare bone is left. After removing the cartilage from the rectangular block of bone, this block is countersunk into the bed from which it was removed, thus giving fresh bony contact across the sacroiliac articulation. This gives a firm bony fusion at the joint. The incision is closed in layers. attaching the periosteal muscle flap back to the crest of the ilium as in the Smith-Petersen incision for exposing the hip joint. In some clinics a double plaster spica is applied. In others the only form of postoperative immobilization is a brace or rest on a Bradford frame.

*This operation allows complete obliteration and solid intraarticular bony fusion* of the sacroiliac joint. In certain cases where there is much destruction about the joint, it may be advisable to attempt stabilization by extra-articular methods.

Campbell's Operation.—Campbell uses an incision similar to that described in the Smith-Petersen operation (Fig. 876). This is carried down to the bone where the periosteum is incised and elevated for a considerable distance, thus exposing the posterior portion of the dorsum of the ileum. The crest of the ilium is dissected to raw bone and the adjacent fibrous tissue is removed from the posterior surface of the sacrum beneath the region of the erector spinal or sacrospinal muscles. A portion of the crest is removed and preserved. The inner surface of the overchanging portion of the crest of the ilium and the adjacent posterior surface of the sacrum are denuded, making a raw gutter parallel with the sacroiliac joint, formed by the posterior surface of the sacrum and the inner surface of the ilium posterior *to the sacroiliac joint* (Fig. 877). Into this space is placed the graft from the crest. Multiple grafts or "shavings" are next secured from the dorsum of the ilium and placed in the gutter until the space is well filled. The wound is closed in layers and the patient is placed on a Bradford frame for a period of six weeks. Bony fusion occurs between the sacrum and the ilium posterior to the sacroiliac articulation

## References

*(For References see Chapter 67 )*

CHAPTER 67

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M. JOSIAH HOOVER, JR.

## OSTEOMYELITIS

### General Considerations

Acute hematogenous osteomyelitis is an inflammation of bone secondary to a blood stream infection. The infection may be acute, subacute, chronic, or residual. The surgical procedures vary, as well as the indications for surgery, according to the stage of the disease. Acute hematogenous osteomyelitis is caused by the hemolytic *Staphylococcus aureus* in the large majority of cases. The streptococcus is the next most common causative organism. Here, only osteomyelitis caused by pyogenic organisms is considered. Males are affected twice as frequently as females, as boys are subject more frequently to trauma than are girls. Acute hematogenous osteomyelitis is principally a bone infection of childhood and adolescence. The active growth period, the presence of epiphyseal cartilage, and the hairpin capillary loops are factors in its localization. The capillary loops and the medullary spaces of the epiphyses permit the bacteria to lodge in the metaphyseal region because of the slowed circulation at this point. In adults it is infrequently seen after the epiphyses have closed, because this anatomic relationship ceases to exist. A focus of infection as a furunculosis or tonsillitis may be the route by which the organisms enter the blood stream. The elective tonsillectomy and the use of the antibiotics, as penicillin and others, have been two important factors in the marked decrease in the occurrence of this bone infection.

*Acute osteomyelitis* may be the result of direct extension of the infection in adjacent tissues. The bone felon, the phalanx being involved secondarily to infection in the finger pulp, is an example. In compound fractures osteomyelitis may occur from direct implantation of the organisms.

The metaphysis near the epiphyseal line is agreed by most to be the site of the primary bone infection. A bone abscess develops as the bacteria multiply, since the bone plays no part in walling off the infection, and the abscess gradually increases in size. Because the cartilaginous plate blocks its spread, the infection passes through the cancellous bone to the subcortical zone and through the cortex to the subperiosteal area. An abscess is formed at this point, stripping up the periosteum. The infection may reach the medullary cavity retrogradely by way of the Haversian canals (Fig. 878). The infection beginning in the metaphysis may extend the entire

shaft length. The necrosis of bone may be due to the thrombosis of the vessels, or to the effect of the staphylococcic toxins, and may vary from a localized area, usually at the metaphysis, to the entire shaft of the bone. The adjacent joints may become involved by extension through the epiphysis or along the epiphyseal line in high attachments of the joint capsule. The subperiosteal abscess may rupture through the periosteum and break through the skin, evacuating its contents by way of the sinus formed.

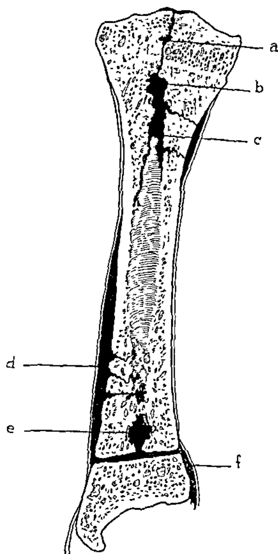



Fig 878 —Routes of spread in acute osteomyelitis of a long bone. *a*, Rupture of pus through epiphysis into joint. *b*, Focus in metaphysis with direct extension to medullary cavity. *c*, Pus in medullary cavity passing through Haversian canals to subperiosteal space. *d*, Pus in subperiosteal space passing through Haversian canals to medullary cavity. *e*, Focus in metaphysis with separation of epiphysis and elevation of periosteum *f*, Pus dissecting beneath capsular ligament into joint in high insertion of capsule. (Semidiagrammatic.)

Dramatic constitutional symptoms accompany the onset of acute osteomyelitis. Pain, which is frequently severe, aching and throbbing in character, a chill followed by a high fever, general malaise, inability to use the affected part, and leukocytosis are the early signs and symptoms. Pain at the site of the lesion is usually the first symptom. The absence of lymphangitis and lymphadenitis may help to rule out a cellulitis of the overlying tissues. The x-ray is of little diagnostic value for the first ten days or two weeks unless a neoplasm is present. The use of antibiotics may prevent entirely the roentgenographic changes The first change in the bone is

rarefaction at the location of infection due to absorption of lime salts. The treatment in the acute stage with penicillin or other antibiotics ideally should be instituted long before there are x-ray findings. To defer treatment until x-ray findings are seen is inexcusable, as irreparable damage will have occurred.

### Treatment

It is more and more the consensus that early surgical drainage of the focus is no longer indicated. Before the era of antibiotics it was the general opinion that acute osteomyelitis should be treated as a surgical emergency, resecting bone to relieve intramedullary pressure and establishing drainage. The trend has been toward more conservative surgical treatment of acute osteomyelitis since the introduction of antibiotics. In most cases the bacteremia is controlled and the progress of the infection is stopped. Acute osteomyelitis with or without septicemia should be treated early with penicillin and other antibiotics. Surgery should be postponed until a soft tissue abscess has formed and can be diagnosed clinically. An exception to this may arise where the patient fails to respond to the antibiotics, and surgical intervention becomes imperative, but this should not be done until after an adequate and a thorough trial of the antibiotics.

The soft tissue abscess may be treated by multiple aspirations or by surgical drainage. It is still a questionable matter as to whether or not a small opening through the cortex should be made to allow intraosseous drainage. One may reason that little additional harm can be done by drilling four to six holes in the cortex.

If intraosseous drainage is deemed necessary, the point of maximum tenderness is marked out before the required general anesthesia is given. The nearby joint, blood vessels, and nerves should be avoided in the incision. A slightly curved incision, as suggested by Bancroft, with the convexity anteriorly, may give better drainage. The periosteum is incised through a short incision, 1.25 to 2.5 cm. in length. The stripping should be minimum. Several holes are made with a drill into the medullary cavity. If pus is not found, the wound is closed in layers without drainage. Further attempts to locate the supposed infection will weaken the bone. If the focus has been missed, the pus will rupture into one of the drill holes

If the medullary cavity contains pus, a trap door 1 25 cm. by 2.5 cm. is outlined with drill holes and removed with as little trauma as possible. The detritus in the cavity is gently removed. No curettage should be done. If pus is found subperiosteally, the surgeon will have to decide as to the wisdom of draining the medullary canal Each case must be treated on its own individual situation. The morbidity and mortality are increased according to the extent of the procedure.

The wound should be packed open with light petrolatum gauze. This is done to promote drainage and should be loosely placed. With the extremity in the position of function a plaster cast is used to immobilize the joints proximal and distal to the operative site. The drain is left in place for six weeks. The spread of infection to joints must be held in mind as a possibility so that prompt aspiration and drainage may be instituted as well as methods of preventing pathologic dislocations. This is especially true of the hip joint.

The patient may not be seen until the second stage of the disease. Large soft tissue abscesses resulting from the rupture of a subperiosteal abscess may be

present, or there may have been inadequate subcutaneous abscess drainage. In such cases penicillin or other antibiotics should be given. Drainage should be instituted. Repeated small transfusions of blood may be of great value, and other general supportive measures should be used.

Depending upon the response to penicillin the drainage may not persist after the incision, and the wound heals. However, if necrotic bone remains, suppuration continues. The x-ray will reveal the sclerosed sequestra surrounded by involucrum of new and often imperfectly formed bone.

The individual case must be studied as to the most satisfactory surgical procedure in the treatment of chronic osteomyelitis. Sufficient time must have elapsed for the involucrum to be rigid enough to preserve the shaft contour after sequestrectomy. The humerus and the femur are sites where it is of importance to be certain of the adequacy of the involucrum. Indiscriminate destruction of bone may lead to further sequestra and thus prolong convalescence. The proximity to the epiphysis must be kept in mind in order that growth disturbances be avoided. The sequestrum should be removed when the x-ray reveals the line of demarcation between the dead and living bone.

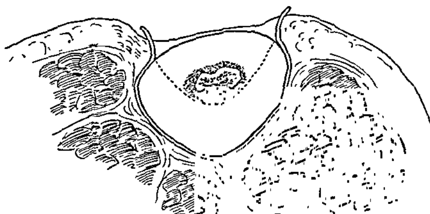


Fig 879.—Sequestrum and area of involucrum to be removed in order to avoid cavity formation in the bone.

The operation of sequestrectomy is indicated in the presence of large sequestra (Fig. 879). The incision should be sufficient to remove the sequestrum and the periosteum is incised and retracted. The involucrum over the sequestrum may be hard and is best removed by using multiple drill holes to outline the part to be removed. It is removed so as to allow exploration of the cavity containing the sequestra. The fragments are removed with the granulations lining the cavity. The detritus and exudate are curetted from the medullary canal and all of the sinus tracts are excised. Bennett's method for outlining the sinuses is ingenious and practical. Methylene blue dye and hydrogen peroxide solution in a mixture are instilled under pressure into the sinus tract with a syringe. The hydrogen peroxide in contact with the necrotic material carries the dye into the smaller recesses of the bone cavity Thus outlined with the blue dye, the sinus tracts can easily be excised and can be followed to the innermost recesses. After removing the bony fragments and unhealthy granulations lining the sinus tracts, the cavity is "saucerized" by rongeuring off the overhanging margins of bone. Here again it best be mentioned that unnecessary periosteal stripping should be avoided as well as avoidance of

unnecessary trauma. Otherwise, a vicious cycle may result requiring later operations for removal of necrotic bone which resulted from unnecessary denuding and trauma. The crest of the tibia should be preserved if possible in saucerization of the tibia, for the crest gives strength and the contour of the leg is maintained. With adequate antibiotic therapy, if the infection be low grade and the drainage slight, one may close the wound primarily. If closure is not plausible, the wound is packed with petrolatum gauze and a sterile dressing is applied. A cast is applied over the leg and immobilization is carried out during convalescence.

This cast is not removed until four to six weeks have elapsed, unless pain or fever warrant inspection of the wound. The cast should be continued until there is complete healing. One should observe aseptic technic in dressing the open infected wound. The wound may be closed secondarily if there is little infection after elapse of several weeks, and in some cases a split thickness skin graft may be used over the granulating wound.

Compound fractures may be followed by a localized chronic osteomyelitis. The infection may be limited, requiring only a simple sequestrectomy. If internal fixation has been used, as plates and screws, this should be removed, and if there is nonunion at the fracture site, the infected tissue must be excised with the removal of dead bone. Petrolatum packing is used with casting until the wound is [illegible] or the wound is permitted to granulate from the bottom up. After the wound [illegible] healed, a bone grafting operation will be necessary if nonunion is present.

The so-called Brodie's abscess is a low-grade localized osteomyelitis and is [illegible] cated by x-ray examination. The treatment consists of the use of penicillin [illegible] antibiotics and unroofing the involved area. The cavity can be detected by [illegible] drill point which will drop into the cavity as one sounds for it. The cavity [illegible] roofed, and the walls are curetted. With the use of antibiotics, unless [illegible] symptoms of a severe infection, the wound may be closed. A secondary [illegible] be necessary following drainage, if drainage is instituted.

In some cases where enough of the involucrum cannot be removed [illegible] soft tissues to fill the cavity completely, a dead space results No [illegible] should be placed in this infected cavity in an effort to fill this defect, [illegible] of an adjacent muscle with blood supply may be sutured into the cavity.

Various plastic procedures have been used to hasten healing in [illegible] ing the saucerization of superficial bones. Davis recommends lateral [illegible] and subcutaneous tissue shifted in by the French method and secured [illegible] of the gutter by tacks or sutures passed through drill holes in the bone [illegible] 881, and 882). Lord, using much the same method, secures suffic[illegible] tissue by lateral relaxation incisions and thus avoids extensive under[illegible] subcutaneous tissue and interference with the lymphatic channels (F[illegible] states that this procedure can frequently be done with safety at the [illegible] saucerization as the resistance of the host and the relative avirulence [illegible] ism permit it. This method is also of value in the excision of thin [illegible] resulting from operations upon the tibia. As these scars frequent[illegible] sometimes undergo malignant change, it is safer to excise them [illegible] pad of skin and subcutaneous tissue over the prominent tibia. D[illegible] be permitted to fill up with granulations before skin grafts are [illegible] as Brunschwig has pointed out, these pockets may behave much [illegible] and continue to drain.

The Orr method is probably more effective and is not so laborious and so painful a procedure. In 1920 Orr first used the method of "immobilization and rest" in the treatment of chronic osteomyelitis. The five principles of the Orr treatment

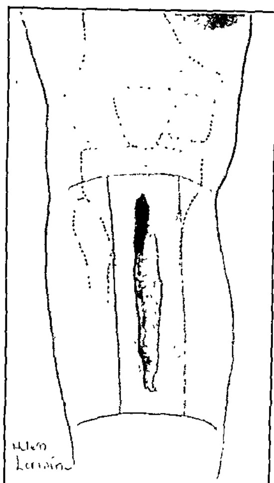


Fig. 880—Persistent cavity in upper end of tibia with lines of incision for mobilization of skin flaps after the French method (Redrawn from Davis)

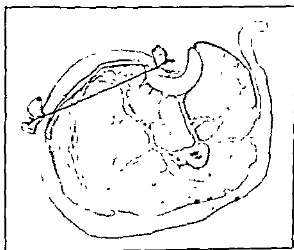


Fig. 881—The skin flaps have been shifted inward and fixed at the bottom of the defect in the bone The sutures are tied over gauze rolls (Redrawn from Davis)

are: (1) Immobilize the patient at once in the best position possible on the operating table (2) Do a thorough débridement or drainage operation if necessary. (3)

Pack the entire wound open with sterile petrolatum gauze, using no sutures or drainage tubes. (4) Apply an extensive well-fitting plaster of Paris cast. (5) Do not disturb the cast, the wound, the dressing, or the injured part except for definite complications. Orr states that by this method the vital resources of the patient are conserved, limbs and lives are saved, the patients are more comfortable, and there is less trouble and expense in caring for them. The method has definite advantages, especially with regard to the ultimate healing of the bone, the comfort of the patient, and the shortened hospital stay. The Orr treatment has one obvious disadvantage—the offensive odor which increases each week that the cast remains on the limb. The method is especially useful in children, for they tolerate restraint well, do not object to the odor, and are spared the discomfort of frequent painful dressings.

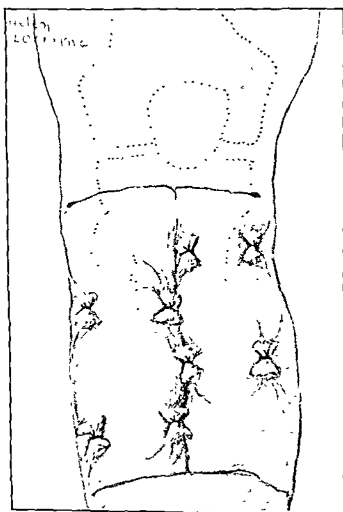


Fig 882 —Appearance of the leg after suturing is complete. Note the alternating position of the sutures (Redrawn from Davis)

Shortly after the war of 1914-1918 the late William S. Baer introduced the maggot treatment of chronic osteomyelitis. His observations of uncomplicated healing of compound fractures infested with maggots led to his first use of these scavengers in osteomyelitic wounds. This method was used widely and with success up to the era of chemotherapeutic agents and antibiotics. The technic is as follows:

The saucerization operation as described above is carried out. Two or three days after this operation the skin is cleaned with sterile water and care is taken

that no antiseptic be applied to the field. The wound is filled with two-day-old maggots. The maggots are kept in the wound by a wire cage which rests on a sterile rubber mat. The rubber mat is sealed to the skin with collodion. The wire screen prevents the escape of the maggots. The area is exposed to the light or to an electric baker. The light keeps the maggots in the depths of the wound. At the end of five days the maggots are washed out of the wound and a fresh lot placed in the wound. This process is repeated until the wound has healed. Seven to ten applications may be required. In six to eight weeks healing is complete. A longer time is required in adults.

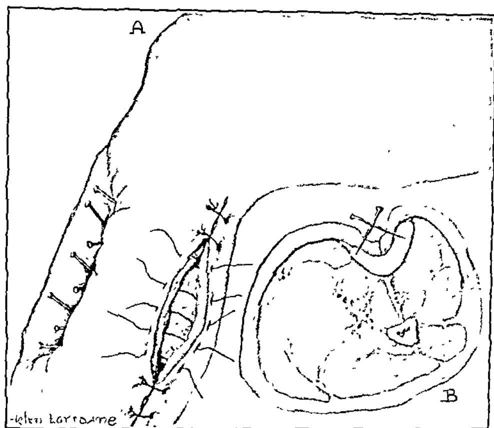



Fig. 883.—Shifting in of skin flaps by method of Lord *A*, Note the relaxation incision *B*, *The skin flaps are held in position by small nails (Redrawn from Lord.)*

The maggots act as scavengers, removing the necrotic tissue, ingesting the bacteria, and excreting allantoin which promotes granulation and wound healing. The one objection patients made to this form of treatment was that they felt a "sucking sensation" when the maggots were at work. The introduction of the antibiotics has led to limited use of this method.

The success in the treatment of chronic osteomyelitis depends largely upon the use of the antibiotics and the careful yet thorough removal of the affected areas at the time of operation. Each method of treatment has its merits. Each individual case must be treated by the method best suited to it.

## BURSITIS

Bursae are endothelium-lined sacs that protect delicate structures from pressure. There are bursea normally found and there are bursae that develop at the site of repeated trauma. The olecranon and prepatellar bursae are examples of the former.

The bunion is an example of the latter. Bursae being similar to other endothelium-lined structures are subject to trauma and infection. A traumatic bursitis may be acute or chronic, resulting from repeated trauma, and an infection in a bursa may also be acute or chronic. The shoulder and elbow and knee regions are the sites where bursae are most frequently involved as the result of trauma or infection.

The infected bursae, if suppurative in type, require prompt surgical incision. The bursae about the knee are not infrequently infected. In children and in athletes, especially football players, superficial abrasions over the kneecap are received and are frequently neglected The abrasion becomes infected, and direct extension infection is spread to the bursa. This bursa should be widely incised by making two lateral incisions, evacuating the pus, and free drainage should be instituted. The use of antibiotics and hot wet dressings is indicated. The bursal infection may heal promptly or it may become chronically inflamed requiring excision of the bursa.

Trauma to the olecranon bursa is of frequent occurrence, leading to a bursitis. This bursa lies over the subcutaneous olecranon process, and because of this superficial location it is often traumatized. Miners striking the elbow against the walls in their close quarters cause the bursitis known as "miner's elbow." Draftsmen and students leaning on their elbows at their endeavors traumatize this bursa. The reaction to trauma is a rapid effusion of bursal fluid leading to an enlargement of the bursa so that a cyst filled with fluid presents itself. A similar condition occurs about the knee with the prepatellar bursa, when it is involved. Those who work on their knees are liable to have so-called "housemaid's knee." This acute traumatic bursitis may be treated with aspiration under strict aseptic technic with the use of a compression bandage. After aspiration, if the cyst recurs and persists, it may be necessary to excise the entire bursa. If there is frequent recurrence of the injury to the bursa, the lining of the sac becomes thickened and synovial tags are broken off, resulting in loose bodies within the sac. These bodies serve for further trauma. If the bursa becomes inflamed, the treatment of choice is excision. However, circumstances may require only an incision of the bursa with removal of the loose bodies. The bursa that has become thickened may be rather easily removed through a transverse or an elliptical incision The sac can usually be dissected out in toto either by sharp dissection or by using a gauze sponge over the index finger as the dissector. The wound is closed with black silk sutures after controlling the bleeding with ligatures or with the cautery. The elbow and knee bursae are cared for in a similar fashion.

Bursitis in the subacromial and subdeltoid regions resulting from the repeated trauma of the gliding of tendons across the shoulder joint is a condition encountered with considerable frequency. Because of the type of motion in the shoulder joint with the biceps and supraspinatus tendons making their attachment at the glenoid of the scapula and the greater tuberosity of the humerus, respectively, the subacromial bursa is often traumatized. There may be an acute inflammatory reaction which subsides, but calcium may be deposited in the subacromial bursa as a result of Nature's effort to protect the traumatized supraspinatus tendon. The inflammatory reaction to this calcium deposit may cause considerable pain, requiring the use of opiates for its control. Many ways of treating this condition are in use. X-ray therapy is frequently used with satisfactory results, and diathermy may give prompt relief. Irrigation with procaine 1 per cent solution may relieve this con-

dition. Infrequently the bursa gives such discomfort as to require incision and removal of the calcium deposition, and when it is removed there is dramatic relief. The subacromial bursa is exposed by an incision beginning midway between the coracoid and acromion processes and extending down in line with the fibers of the deltoid muscle for about three inches. The muscle fibers are separated, exposing the bursa. The sac is either excised or incised. The wound is closed, and active and passive motion is begun as soon as tolerated by the patient.

## INGROWING NAIL

Operative excision of the lateral border of the nail matrix is indicated when conservative measures fail to control the problem of an ingrowing nail. The recurrence of the ingrowing nail is prevented, for, if done correctly, no nail returns after the operation. This procedure can be carried out under local anesthesia. The dorsal and plantar digital nerves are blocked on both sides at the base of the toe.

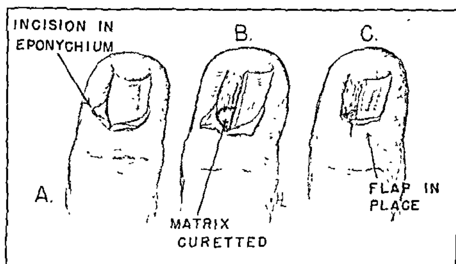



Fig. 884.—Heifetz operation for ingrowing toenail *A*, Incision in eponychium. *B*, Nail bed curetted after removal of outer third of nail. *C*, Flaps turned back in place, requiring no sutures. (From Heifetz: Am J Surg 38· 298, 1937.)

An incision is made in the eponychium extending 1.5 cm. (Fig. 884). The lateral one-third of the nail is incised from the tip to the base by cutting the nail from before backward with the cutting edge of a sharp-pointed knife. This involved portion of the nail is removed. The lateral corner of the matrix is exposed and thoroughly curetted If any part of the matrix is left, a splinter of nail may grow out, causing a continuance of the problem. The granulating tissue at the nail fold and the nail bed are left undisturbed. The flap of eponychium folds back over the site of the removed matrix, making sutures unnecessary A petrolatum gauze dressing is placed over the wound. A sterile pressure bandage is then applied. The patient may be ambulatory in a shoe with the tip cut out. The infection rarely causes significant trouble when this procedure is used It may be necessary, however, to use penicillin and warm hypertonic foot soaks of Epsom salts.

## BUNIONS AND HALLUX VALGUS

The hallux valgus may not be pronounced in this condition. The exostosis on *the medial surface of the head of the first metatarsal may be excised and no other*

operation indicated. An incision for the removal of the exostosis is made over the medial surface of the first metatarsal. The incision is curved dorsally and extends on to the proximal phalanx of the great toe. The bursa may or may not be excised. The exostosis is removed with an osteotome and the surfaces are carefully rounded off. The wound is closed with several fine catgut sutures in the fascia and black silk sutures in the skin. The patient may be allowed up on the third or fourth day, wearing a shoe with its toe cut out. If hallux valgus, which is the deviation of the great toe to the lateral side of the foot, is significant, surgical correction must be done at the time of the exostosectomy. This entails plastic procedures in addition to the excision of bone. In the Mayo operation, the head of the first metatarsal is excised. However, this removal of bone weakens the anterior arch of the foot. The Keller operation resects the proximal part of the first phalanx of the great toe and is especially useful in hallux rigidus.

Silver's operation is excellent for both removal of the exostosis and correction of the hallux valgus. The usual curved incision is made with convexity downward over the joint. The capsule is exposed and the bursa excised. A Y-shaped incision is then made through the capsule to the bone so as to give three flaps—one dorsal, one plantar, and the third distal, with base the width of the proximal phalanx (Fig. 885). The last flap is carefully freed and reflected in order to serve as the internal lateral ligament. The other two are reflected from the metatarsal bone, exposing the exostosis, which is excised with a thin layer of cortex (Fig. 886). A capsulotomy of the capsule on the outer side of joint is then done. With the toe strongly dorsiflexed, a tenotome is inserted between the head of the metatarsal and the capsule, and a longitudinal dorsal incision is made in the capsule (Fig. 887). Then the toe is strongly plantar flexed and a similar plantar incision is made. The toe is strongly adducted and the two incisions are connected by a vertical incision through the outer portion of the capsule, thus giving an outer capsular flap with a proximal base (Fig 888). This allows correction of the deformity The toe is brought into strong adduction to produce overcorrection and is sutured thus by drawing the distal flap on the medial side of the joint strongly backward and suturing it here to the periosteum of the metatarsal (Fig. 889). The two proximal flaps are then sutured over it (Fig 890) and the incision is closed in layers. The patient may be permitted early ambulation, and shoes are worn in about two or three weeks.

Stein's operation for hallux valgus, while somewhat more difficult, is based on sound anatomical reasons and gives excellent correction of the deformity without requiring an osteotomy of the first metatarsal.

The operation is performed preferably under a tourniquet. A longitudinal incision, about 3.75 cm in length, is made on the dorsum of the foot, in the interval between the first and second metatarsal heads (Fig. 891). This extends from behind the web directly posterior. Dissection is carried down, keeping close to the lateral aspect of the capsule, thus exposing the lateral sesamoid with its adductor obliquus attachment, the conjoined tendon, and the lateral head of the flexor brevis muscle With the joint line as a guide, the external lateral ligament with the part of the capsule intervening between it and the lateral sesamoid is divided by a hockey stick incision This is begun by dividing the external lateral ligament at the joint line, is c[illegible]

of the h[illegible] margin

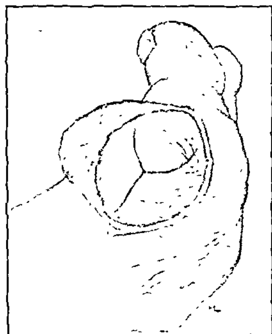


Fig. 885.

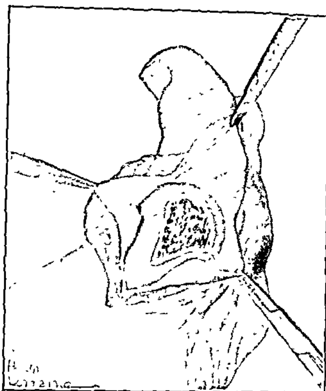


*Fig. 886.*

Fig. 885.—Silver's operation for hallux valgus Y-shaped incision in capsule.
Fig 886.—Silver's operation for hallux valgus. The exostosis has been excised

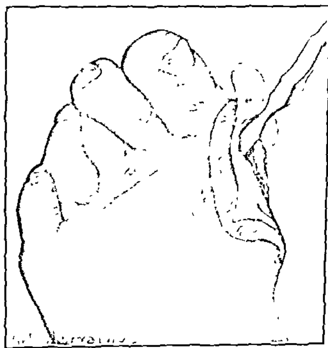


Fig. 887.—Silver's operation for hallux valgus With a tenotome the lateral capsular flap is made.

The attachments of the obliquus tendon to the exposed lateral sesamoid are thoroughly divided. The hindmost fibers, which are attached to its posterior tip as a separate bundle, must be divided. The attachments of the conjoined tendon to the base of the proximal phalanx distally and the red fibers of the flexor brevis muscle proximally act as guides to insure its complete division. The conjoined

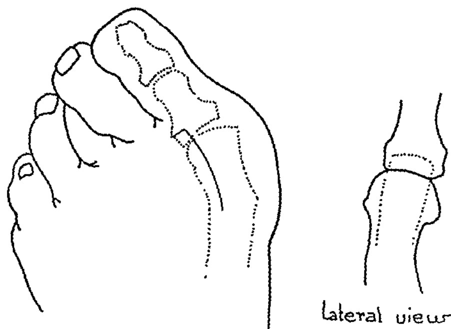



Fig. 888.—Silver's operation for hallux valgus. Diagram outlining the capsulotomy on the lateral side of joint.

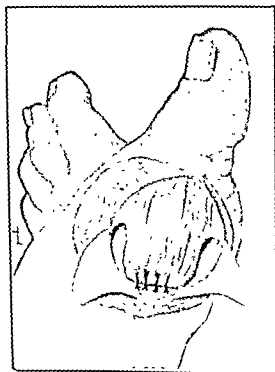


Fig. 889

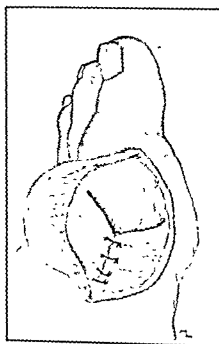


Fig. 890.

Fig. 889.—Silver's operation for hallux valgus. Suturing the distal capsular flap so as to adduct the great toe.

Fig 890.—Silver's operation for hallux valgus. The suture of flaps completed.

tendon gains length. Frequently, the lateral head of the flexor brevis also requires division, which should be performed proximal to its sesamoid attachment. A definite "give" can be felt when the binding structures at the posterior sesamoid tip are released. It is but rarely that a triple, subtotal resection of the obliquus tendon is found necessary. Unresisted correction of the valgus, without any tendency to spring back or undue joint tension, is now possible. The sesamoids slip into place voluntarily.

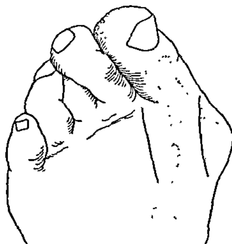


Fig 891.—Incisions in Stein's operation for hallux valgus.

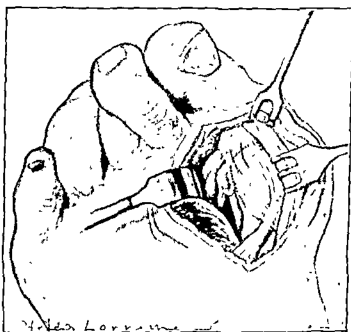


Fig 892.—Exposure between heads of first and second metatarsals, showing hockey stick incision in lateral capsule, the lateral sesamoid and muscular attachments in this area.

The heads of the first and second metatarsals are approximated by a heavy silk or fascial suture. This is taken through the opposing aspects of the capsular bases or through adjoining drill holes.

A second, dorsally curved incision is made on the medial aspect of the joint, exposing the bursa, the thickened, fibrocartilaginous capsule, and the displaced abductor tendon. The bursal sac is excised. A modified Silver capsular flap is fashioned so as to permit foreshortening of the elongated capsule, derotation of the

everted toe, and replacement of the displaced abductor tendon. Before anchoring this corrective flap into position, the head of the metatarsal is inspected. If hypertrophy along its medial margin is sufficient to act as a bone block against complete correction of the valgus, or to result in undue joint tension after correction, the obstructing bone only is chiseled away. As far as possible the ball of the toe, the groove for the medial sesamoid, and the inner cartilaginous rim at the periphery are conserved. The tubercle of origin of the internal lateral ligament, if enlarged, as well as any osteophytic process, is removed. If, after correction of the valgus, the extensor tendons are short, these may be corrected by triple subtotal sections.

Holding the toe in the desired degree of correction, the capsular flap is now anchored snugly. Silk sutures are preferable. Overcorrection is avoided and freedom of mobility should be present before and after suturing. The skin incisions are closed and the position is held with adhesive plaster. Weight-bearing is permitted after two weeks, but a Jones bunion splint is worn at night for several months.

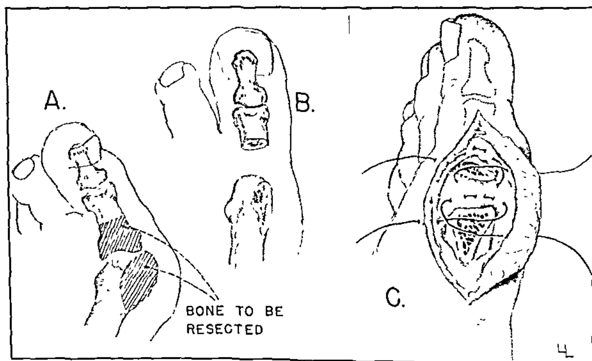



Fig. 893—Keller operation for hallux valgus. *A*, Bone to be resected from the base of the proximal phalanx and head of metatarsal is indicated by dotted lines. *B*, Resection of bone *C*, Closure over resected phalanx by figure-of-eight suture. (From Keller. New York M. J 95: 696, 1912)

The Keller operation is used in cases where there is marked deformity and also in the presence of arthritic changes. A curved dorsal incision is made over the metatarsophalangeal joint on its medial side. By subperiosteal dissection the base of the first phalanx is exposed. The exostosis on the head of the first metatarsal bone is carefully and smoothly excised with an osteotome. The base of the phalanx is excised with a sharp osteotome or a small Gigli saw. This allows the toe to be placed in an overcorrected position medially (Fig. 893). The capsule and periosteum are closed with fine catgut sutures and the skin is closed with black silk. A plaster slipper is applied so as to hold the toe in abduction and slight flexion. Ten days or two weeks postoperatively the patient is permitted weight-bearing in correct shoes.

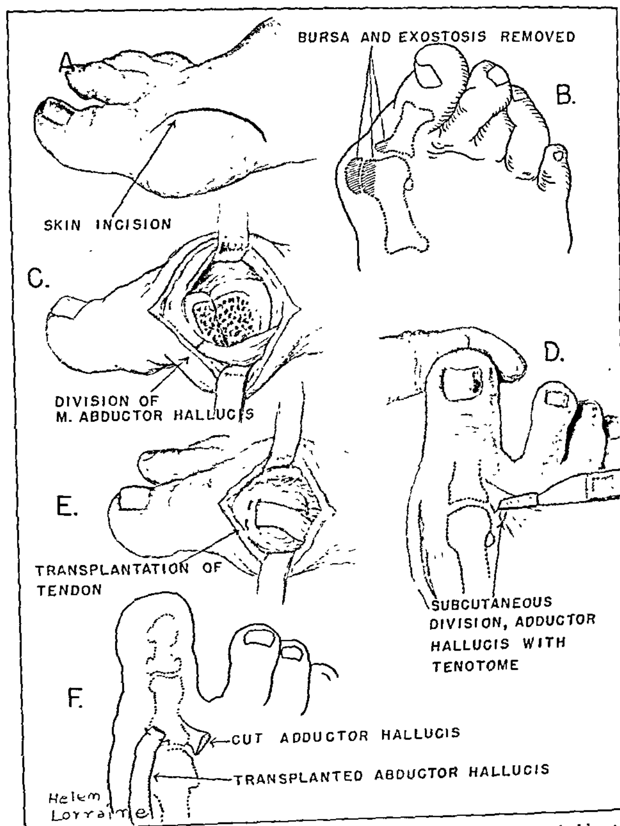



FIG. 894.—Hauser operation for hallux valgus. *A*, Skin incision. *B*, Removal of bursa and exostosis. *C*, Exposure of abductor hallucis muscle. *D*, Subcutaneous tenotomy of adductor hallucis *E*, Transplantation of abductor hallucis tendon. *F*, Completed. (From Hauser: Diseases of the Foot, W. B. Saunders Co, 1950)

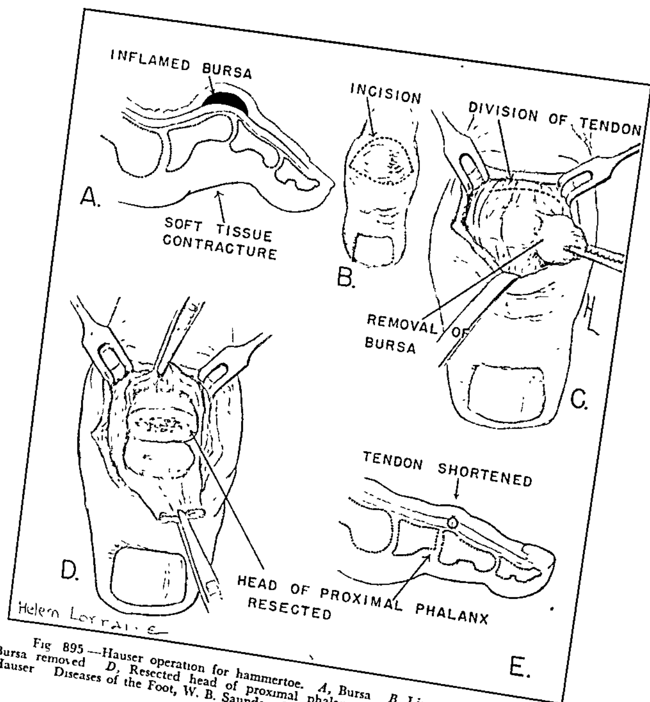



Fig 895—Hauser operation for hammertoe. *A*, Bursa *B*, Line of skin incision. *C*, Bursa removed *D*, Resected head of proximal phalanx. *E*, Shortened tendon (From Hauser Diseases of the Foot, W. B. Saunders Co., 1950)

Hauser's operation seems to be satisfactory for correction of the hallux valgus (Fig. 894). An elliptical incision is made dorsally over the medial side of the metatarsophalangeal joint and the bursa is excised. After the abductor hallucis tendon is identified, it is freed from its insertion. The shortened adductor tendon and the contracted capsule are divided through a second incision between the first and second toes. The exostosis on the head of the metatarsal bone is excised. The toe is carried into a varus position and the capsule is sutured. The abductor hallucis tendon is sutured to the base of the first phalanx on its medial side and slightly dorsally. The skin is closed and a plaster cast is applied. Walking on the cast is permitted as soon as the wound heals. Corrective shoes are worn postoperatively.

## HAMMERTOE

In the operation of Hauser the distal end of the proximal phalanx is resected. Local infiltration of procaine 1 per cent, as anesthesia, is adequate. An oval incision is made over the skin, excising the corn and bursa. The extensor tendon is divided The head of the proximal phalanx is removed with bone-cutting forceps. (Fig 895.) Sufficient bone is excised. The wound is closed by suturing the extensor tendon and skin with several black silk sutures. Weight-bearing is begun in a shoe with the toe cut out as soon as the patient wishes This procedure does not leave a stiff awkward toe.

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# CHAPTER 68

# GENERAL PRINCIPLES GOVERNING AMPUTATIONS; AMPUTATIONS OF THE UPPER EXTREMITIES

M. JOSIAH HOOVER, JR.

In the preantiseptic era amputations were the most frequently performed operations, and surgeons took great pride in their skill and celerity in doing them Before the introduction of anesthetics, it was essential that operations be completed in as short a time and with as little pain as possible; consequently, the method of transfixing limbs with an especially devised long knife and of dividing tissues from within outward was the accepted way of doing amputations. Under the circumstances, this method served a useful purpose, for minimizing pain was of the utmost importance, taking precedence even over the immediate control of hemorrhage. Also, in the absence of aseptic technic, accurate closure was not permissible, so careful dissection and division of the various tissues at different levels was not only unnecessary but inadvisable. Since the introduction of anesthetics the necessity for great speed has disappeared, and following the development of asepsis the method of carefully approximating wounds has resulted in an entirely different technic for amputations, as well as for other operations.

Because of these advances in the art and science of medicine, a more conservative attitude toward amputation surgery can be assumed. In the wake of the Civil War there were 52,000 surviving major amputees, while there are but 17,000 such survivors of World War II. These figures would indicate that many serious injuries of the extremities were salvaged as a result of the progress made and applied to modern military surgery. The indications for amputations have changed. The development of gas bacillus infection in an extremity, a few years ago, was an indication for immediate amputation. With the advent of antibiotics and the use of antisera, most of these infections can be treated by more conservative measures.

With the changes in the indications for amputations and the development of modern technic, the levels for amputations that may be functioning levels have changed. This is largely due to the improvement in prosthetic appliances. Although it is desirable to have a long stump, requiring less effort for manipulation of the appliance, the improvements in fitting artificial limbs and distributing weight-bearing have decreased the length necessary for their manipulation. Amputation does not end with the closure of the wound but extends through the successful rehabilitation of the patient after the fitting of a satisfactory artificial appliance

While many different problems arise in connection with amputation of the upper and lower extremities, there are certain general principles applicable to all amputations Progress has been made in the application of the principles rather

than in the development of new operations and technics. The objective of all amputation surgery is to form a good, durable stump, to fit a comfortable prosthesis, to train the amputee in its proper use, and to guide him to a sound mental attitude.

The stump is the criterion for amputation surgery. A useful and comfortable stump is the goal when a prosthesis is to be used. A satisfactory stump is dependent upon the use of the best possible aseptic technic. The development of infection in clean cases with carefully approximated tissues is a disaster. It means edema and congestion of the soft tissues and loss of the skin, or even loss of length. Gentleness in handling tissue and prevention of contamination will help prevent this disaster. Even in open amputations in the presence of infection the addition of other organisms will frequently increase tissue destruction and prolong convalescence. In potentially infected fields the silk and cotton suture may serve as a bacterial nidus and, therefore, cannot be tolerated. Systemic administration of antibiotics, especially penicillin, is an additional measure that should be used as a precaution against invasive organisms.

The greatest care should be used in controlling hemorrhage in all operations, and this is especially important in major amputations. Not only should the larger vessels be ligated, but every bleeding point should be controlled. If a tourniquet is used, the large vessels should be clamped and ligated while the tourniquet is still in place and smaller vessels should be secured after it is removed. If a tourniquet is not used, the operator must keep in mind the position of the larger vessels in order to clamp them before they are divided; and it is better to go slowly, picking up bleeding points as they appear, rather than to proceed rapidly, intending to control hemorrhage after the bone is divided; otherwise, much blood will be lost and considerable shock may be produced. If a tourniquet is not used in major amputations, the main vessels should be ligated during the early part of the operation. It is also advisable to conserve as much blood as possible by occluding the artery before the vein, and, when possible, to have the extremity moderately elevated until the vein is tied. Bleeding from bone can be checked with fibrin foam or a muscle tab. Bone wax should never be employed.

The question as to whether a tourniquet should be used depends on many factors, such as the general condition of the patient, the condition of the circulation in the extremity, the presence or absence of infection, especially in the region where the tourniquet would be applied, whether local or general anesthesia is to be used, and, finally, upon the level of amputation. While it is true that a tourniquet may be employed at almost any level, even in shoulder or hip joint amputations, by use of the Wyeth pin or some similar method of holding the tourniquet in place, it is usually better in very high amputations to do a preliminary ligation of the main vessels—the external iliac or common femoral in the lower extremities and the axillary in the upper extremities. By this means serious hemorrhage may be prevented without the blood supply to the flaps being greatly interfered with. In amputations at lower levels a tourniquet may be used if the local circulatory condition is satisfactory One of the chief objections to the tourniquet is that it tends to promote rapid, careless operating, but by its proper use time can be saved and blood conserved. A tourniquet is not used when the local circulation is already impaired or when there is the possibility of infection in the tissues at the level at which it would have

to be applied. After the patient who has had a major amputation returns to his room, a tourniquet should be kept handy at the foot of the bed in case any significant hemorrhage occurs.

## CARE OF BONE ENDS

The bone should always be carefully and completely divided by a saw at a higher level than the rest of the tissues even in the so-called guillotine or, better, open amputation. In fact, if the dissection is carried from without in, each tissue plane should be divided at a somewhat higher level than the preceding one, thus giving the stump the appearance of an inverted cone. This is necessary where closure is essential, regardless of whether formed flaps are to be used or not, for unless this precaution is taken, in open amputations the stump will soon assume the shape of a true cone even though traction is used. Because of the tendency for rapid retraction of the soft tissues in open amputations, stump traction either by adhesive strips or by some other method should be started as soon as possible.

The care of the end of the bone in all major stumps is much the same under similar circumstances. The most satisfactory method is careful removal of a short terminal cuff (1 cm.) of periosteum and removal of all sharp corners, smoothing the bone with a rasp or file. The bone dust is irrigated from the wound with normal saline solution, for this dust might undergo bony proliferation if allowed to remain in the wound These measures help to prevent the development of exostoses and usually give a satisfactory stump. This method, however, is applicable only to clean cases, for if infection is already present or develops later, that portion of the bone from which the periosteum has been removed will sequestrate and a long convalescence and possibly an unsatisfactory stump will result. If infection is present or is apt to develop, it is better to saw the bone squarely across and disturb the periosteum and endosteum as little as possible, in order to prevent the terminal area of necrosis, known as a "ring sequestrum."

In children the fibula tends to outgrow the tibia in below-knee amputations. The fibula should be sectioned high to prevent this overgrowth. Other methods used to prevent this complication are epiphyseal arrest of the fibula, or synostosis of the fibula and tibia. Satisfactory results usually follow high sectioning of the fibula.

The method of handling nerves is of some importance, for there is a tendency, especially for the ends of the larger nerves, to develop bulbous masses, called neuromas, which frequently give rise to pain and tenderness To prevent pain is the aim in treatment of the nerve Nerves are isolated, gently pulled down, and cleanly sectioned with a sharp knife well above the level of amputation, so that on retraction they will be subjected to less trauma The nerve bed should be normal soft tissue free from scar. The larger vessels with the nerves are clamped and ligated with a fine catgut ligature. Two per cent procaine may be injected into the major nerves, perhaps preventing shock to the patient. Gentleness in handling the nerves is the one essential in their treatment. Pulling and tugging on the nerve should be avoided, for the injured nerve will be replaced by scar. The simple nerve section, as described above, has proved itself to be the most effective care of the nerve, thus preventing sequelae that are detrimental

In closed amputations about a joint, the synovial tissue should be excised. The synovial fluid excreted may be sufficient to break down the suture line as a result of pressure within, or a bursa may develop over the end of the stump. This bursa may become painful when the stump is used. In open amputation the synovial membrane is left, since it acts as a barrier to upward spread of infection.

One may ask what should be done with cartilage in disarticulations. In open disarticulations the hyaline cartilage is left to serve as a barrier to upward spread of infection. In closed disarticulations that are major, the cartilage is usually left. In minor closed disarticulations the cartilage is excised in order to create a more shapely stump.

## CLOSURE OF AMPUTATED STUMP

The question of whether to close a stump completely, to drain, or to do an open amputation depends on a number of factors. When the operation is done for infection, the stump should certainly be drained, and if the infection is virulent, especially if caused by anaerobic organisms, an open amputation should be done. Under such circumstances, Warthen inserts silkworm-gut sutures through the flaps but leaves them united, and then places a gauze pack over the stump. When the danger of infection has passed, the pack is removed and the sutures are tied, thus approximating the flaps. On the other hand, there seems to be little excuse for draining a clean amputation wound; this is quite unnecessary if the proper aseptic technic is used, bleeding is carefully controlled, and the tissues are not unduly traumatized. In this connection, it is important to use fine plain catgut for ligatures in all except the largest vessels, and even then the size of the ligatures is less important than the care with which they are applied. Drainage material acts as a foreign body, causing irritation, and also may carry infection from the skin surface into the tissues If in clean cases it is felt for any reason that drainage is necessary, small rolled rubber tissue drains may be used, and removed in from twenty-four to forty-eight hours.

While the above principles are generally applicable to all amputations, there are certain features which do not apply equally to amputations in the upper and lower extremities. In the upper extremities, amputations may be done under either regional or general anesthesia. As a rule, amputations in the lower extremities are best done under spinal anesthesia because very small doses of the anesthetic will suffice Lower extremity stumps usually are fitted with prosthetic appliances and are, therefore, subjected to direct pressure both on the sides and ends, more on the extensor sides and still more on the ends. For this reason it is desirable to place the scar posteriorly when possible and, therefore, to make long anterior flaps. In the upper extremities prosthetic appliances are not used often, but, when used, greater pressure is applied laterally, so equal flaps are made to give a scar on the end of the stump. In general, when there is a choice of skin for flaps, that surface should be chosen which will best withstand trauma, as, for example, the skin of the palms of the hands and soles of the feet; also, as a rule, that on the extensor surfaces of limbs rather than on the flexor surfaces. End muscle flaps are usually not desirable, and in short stumps large masses of muscle on the sides interfere with the use of appliances The end of the bone should, when possible, be covered by broad tendons, as, for example, the quadriceps tendon; the muscles should be sutured to

these tendons laterally so that the muscles cannot retract too greatly. The muscle is used for padding the circumference of the distal end of the bone and not for the sectioned surface.

The size, shape, and position of flaps, as well as the tissues constituting them, will have to depend on the circumstances. In traumatic cases it may be necessary to use lateral flaps or a simple circular incision in order to conserve as much bone as possible, especially if the amputation must be done above the optimum level. In general, when flaps are used, they should have a broad base and their total length should be not more than one and a half times the diameter of the end of the stump

In young, otherwise healthy individuals it is highly desirable to have snugly fitting flaps, although there should never be an undue amount of tension on them. On the other hand, in elderly individuals, especially those with circulatory deficiency in the lower extremities, flaps should be of sufficient length to avoid any tension whatsoever; also, under these circumstances, it is best to make a simple circular incision, as this produces less interference with the blood supply to the skin.

## THE LEVEL OF AMPUTATION

Many factors enter into the decision as to the level at which an amputation should be done. The age, sex, occupation, general health, condition of the local circulation, and even the social status and cosmetic effect should be taken into consideration If, for example, there is a choice between a Syme amputation at the ankle and amputation through the lower third of the leg, the decision would be in favor of the Syme amputation in a man whose occupation keeps him on his feet a great deal, especially if appearances are relatively unimportant; for this amputation gives an excellent weight-bearing stump but is not well adapted to trim-looking prosthetic appliances. In the upper extremities disarticulation at the elbow is usually undesirable, but if a laborer's occupation called for an appliance which could stand considerable direct pull, the bulbous stump might be valuable. If the condition of the local circulation is doubtful, especially in the lower extremities, it is better to amputate at a somewhat higher level than would ordinarily be done. It is wise to mark the level of amputation before applying sterile drapes, in order to avoid amputating at a higher level than is intended. The extremity distal to the level of amputation should be draped in such a manner that it can be removed from the operative field as soon as the bone is divided.

Finally, amputation should not be done at all unless the surgeon is convinced that there is no reasonable chance of obtaining a satisfactory result by more conservative methods of treatment or unless he considers that the patient's life is jeopardized by delaying amputation. If the patient is skeptical as to the wisdom of amputation and if the condition justifies waiting, it is well to defer operation until the patient is convinced of its necessity

## PLASTIC REPAIR AND REAMPUTATION

Many open amputations and most of those which become infected require either a secondary plastic repair, a revision, or a reamputation Since the procedure is an elective one, preparation of the stump for the final repair is possible and frequently necessary. The patient should be in the best possible general condition. If anemia, low plasma protein, or avitaminosis be present, correction of these condi-

tions should be made by the use of whole blood, protein substitutes, and vitamins. The revision should be in a clean field. Edema of the stump should be eliminated by proper rest, elevation of the extremity, and proper bandaging. The skin must be cleared of infections or crusts. Sufficient skin, if possible, is to be made available for revision instead of reamputation when the latter would result in too short a stump for function. Skin traction may be applied to stretch the contracted skin. Failure to maintain traction on the skin at the time of open amputation leads to this contracture.

In order to have a clean field, all deep infection and draining sinus tracts should be eliminated by wide-open drainage. If a focus of infection can be found, this should be excised. Elimination of infection, in so far as possible, is essential, because the chances are that infection will develop in the new wound.

If the bone shows evidence of sequestration, it is probably better to wait until the sequestrum is well formed and can be removed without appreciably disturbing the surrounding tissues. A sequestrectomy should then be done, followed later by either a plastic repair or a reamputation. If there is no evidence of osteomyelitis but simply a granulating wound of the end of the stump, it is better to wait until the wound has healed completely and all evidence of infection has disappeared before doing either a plastic repair or a reamputation. If the granulating wound is unduly slow in healing, the application of pinch grafts may be justifiable, but this should be done with the understanding that the grafts are not to form a part of the permanent covering of the stump but are applied merely to hasten healing. Some authors advise reamputation as soon as the granulating area appears to be relatively clean and careful covering to protect the surrounding tissues from infection, but this seems unwise as there is always infection in the tissues surrounding such a wound. Even after the wound has become completely covered by skin, there will be not infrequently a residual area of indurated, slightly tender tissue over the stump. This indicates that there is still a low-grade infection present, and consequently repair should not be undertaken until the surrounding tissues become soft and pliable.

The question as to whether a simple repair or a reamputation should be done must be decided on the basis of the amount of bone left, the extent of bony damage, and the extent of superficial scar tissue formation. If a lower extremity is involved, as much bone should be saved as is compatible with a good stump end. This is especially important if the amputation be at or above the optimum level.

In plastic repair of a stump the bone is not disturbed unless slight rounding or beveling be required. The operation is mainly on the soft tissues. The scar and granulation tissue are first excised so as not to contaminate the deeper structures. They are excised when necessary to supply the needed skin for covering the stump, and the stump is shaped by this excision into a gently tapering form. The nerves and vessels are cared for as in the definitive amputation, and hemostasis is completed after removal of the pneumatic tourniquet. The skin flaps are closed so that the suture line falls as near the ideal position as possible. The dry sterile compression dressing is applied. Traction to the skin should be *unnecessary*.

Following operation the amputated extremity should be elevated on pillows to lessen edema of the stump. This elevation should be continued for at least five or six days, especially in the lower extremities. On the other hand, it is important not to place the limb on pillows in such a position as to permit continued flexion at the

next joint above, for there is usually a tendency for the limb to become flexed, especially if the stump is short. It is also important that passive motion be started during the first few days. As soon as the wound has healed sufficiently, the patient should be put on a physiotherapy regime including hot baths, massage, and active and passive motion. Lower extremity stumps require active steps for their shrinkage as soon as the wound has completely healed If this is done at an early stage, it will greatly facilitate the fitting of a prosthetic appliance. The stump should be carefully wrapped in some type of elastic bandage, first across the end and then from below upward to the joint above. It is quite important not to include the adjacent joint, as active and passive motion would thereby be restricted.

## FINGERS

In amputation of the fingers or hand there should be a long palmar flap because the skin of the palm is thick and bears usage better than the skin from the dorsum, and it is better nourished (Figs. 896 and 897). However, when it is unusually important to save bone, a circular incision may be made, the bone divided at a slightly higher level than the superficial tissues, and a whole thickness skin graft applied to the end of the finger. According to O'Malley, this gives a very satisfactory covering and does not break down as a result of repeated trauma.

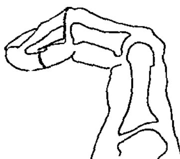


Fig. 896.

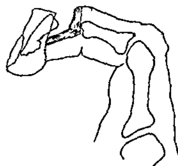


Fig. 897

Fig. 896.—Line of incision for amputation of distal phalanx of finger

Fig. 897.—Showing the method of forming long palmar flap in amputation of finger.

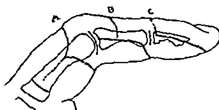



Fig. 898.—Amputation of the finger. *A*, through first phalanx by equal flaps; *B*, through first phalangeal joint by long palmar and short dorsal flap, C, amputation by long palmar flap

The circulation to the fingers is so abundant that they may be crushed apparently beyond the possibility of recovery but still heal and function reasonably well. One finger or a thumb, if the motion is not markedly impaired, is much more useful than a complete artificial hand, as special apparatus can be applied which will enable the patient to grasp objects.

In amputation of the fingers, a rubber band or a soft rubber catheter may be used as a tourniquet, but if local anesthesia is employed, the tourniquet should be applied distal to the line of infiltration. As a rule, it is better to amputate through a

joint (Fig. 898). The anatomy of the finger, especially the insertion of the flexor and extensor tendons, should be borne in mind. The superficial flexors are inserted into the sides of the middle phalanges, and the deep flexors, after splitting the superficial flexors, are inserted into the bases of the last phalanges. The extensor tendons, however, are inserted along the whole length of the dorsal surfaces of the phalanges.

It is unnecessary to suture tendons that function beyond the site of amputation, for each unit of the finger has its own motor power. The extensor tendons are simply cut. The flexor tendons should ideally be severed so that the cut end retracts proximal to the transverse carpal ligament in order that adhesions to adjacent structures will not be formed by the cut end of the tendon.

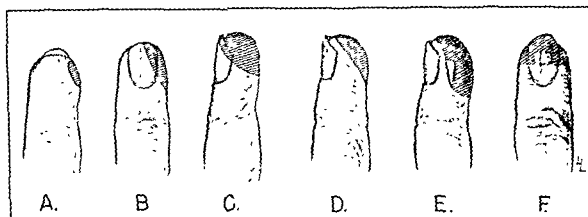



Fig 899—Various types of finger-tip amputations (From Slocum: An Atlas of Amputations, The C V. Mosby Co, 1950.)

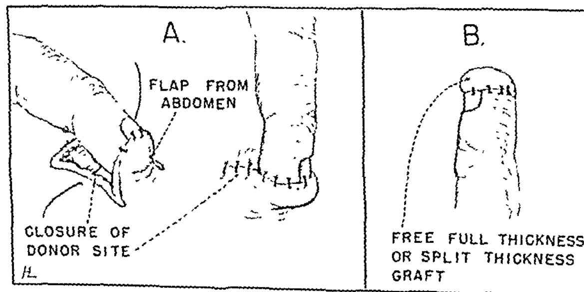



Fig 900—*A*, The amputated finger tip covered with a skin flap from the abdomen. *B*, A split thickness or full thickness skin graft for finger tip

The distal ends of the metacarpal bones and phalanges form the knuckles, placing the joint distal to the knuckle, and the flaps should be shaped accordingly. The webs of the fingers are *about .5 cm* distal to the metacarpophalangeal joints.

Since the sheaths of the flexor tendons of the thumb and little finger communicate with the large palmar synovial sacs, infection in them is more serious than in the flexor tendons of the other fingers. These tendons should be attached to their

sheaths or to the periosteum by a few sutures when the sheaths are opened to preserve their action. The finger should be flexed while the dorsal flap is being cut, and extended when the palmar flap is made. When an amputation is done through a joint, as much as possible of the capsular ligament should be saved in order to cover the end of the bone. The joint is opened first on the back, the extensor tendon is cut, the lateral attachments are then divided, and the flexor tendon is severed last of all.

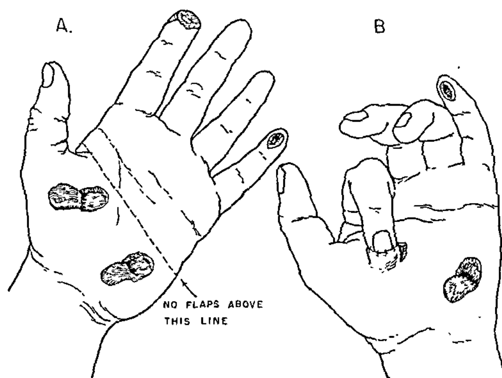



Fig. 901.—Full thickness skin graft from the thumb and hypothenar areas for finger-tip amputation.

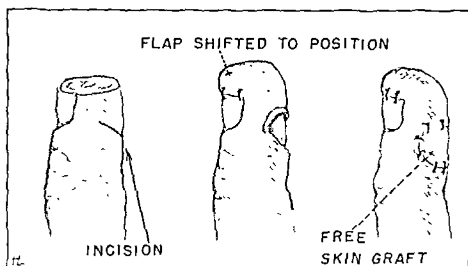



Fig 902.—The sliding flap for finger-tip amputations, using a free skin graft.

Amputations through the finger tips are frequent. In order to obtain a flap to cover the tip of the finger, valuable bone and even the fingernail would have to be sacrificed (Fig. 899). To prevent the loss of length, several satisfactory ways of treatment have been devised Each method is essentially the same, namely, adequate

skin replacement. A free full thickness graft may be removed from the groin, since the skin at this site is very suitable and the donor site scar is not a problem of cosmetics. The amputation site should be gently yet thoroughly cleaned with green soap and water. Local anesthesia of 1 per cent procaine is entirely satisfactory. The wound is débrided and the desired graft is removed from the groin. This graft is cleaned of all subcutaneous fat and is then sutured over the amputation site with fine black silk sutures.

The split thickness graft may be used but is not quite as satisfactory as the above method. A flap graft from the abdomen (Fig. 900) or palm of the hand may be used (Fig. 901). Waughter has described a method by which he uses a sliding flap graft (Fig. 902) The finger is cleaned and anesthesia produced. An incision is made across the palmar surface of the finger, providing the necessary width for the flap. The flap is undermined, then turned over the end of the stump and sutured to the fingernail. A free skin graft is used to cover the site of the sliding graft.

Amputation through the last phalanx should be done, if possible, by a single palmar flap. After the flap is outlined, the extensor tendon is cut and the joint is opened posteriorly, as has just been described. The lateral attachments are divided, and lastly the flexor tendon is cut and is fixed to its sheath or to the periosteum in its neighborhood by fine catgut sutures. After the digital arteries, which are on the sides of the stump, are ligated, the palmar flap is sutured to the dorsal flap with interrupted fine silk sutures.

## THUMB

In amputation of the thumb every reasonable effort should be made to save as much of the thumb as possible. Skin grafts or transplants may be used as a covering. The web may be deepened so that the grasp function is improved, providing there is length enough after this surgery. A transplant of the index finger is only infrequently indicated. The success of the tube and bone graft to replace the thumb is infrequent and usually undesirable.

A disarticulation requires a longer flap to cover the bone than when the bone is divided. If it is impractical to make a long palmer flap, the incisions should be so placed that the palmar flap will be longer than the dorsal. The same method is used in amputating the second phalanx

Disarticulation of a finger or the thumb at the metacarpophalangeal joint may be done by either an oval or a racket incision. When viewed from the back of the hand, the racket incision resembles a Y (Fig. 903). It begins on the back of the metacarpal bone, a short distance proximal to its head, passes downward, crosses the knuckle, and goes obliquely around the palmar aspect of the finger a short distance distal to the web. It is then carried around the other side of the finger in a symmetrical manner, back to the distal end of the dorsal longitudinal incision. This may be made in two incisions, which diverge downward from the back of the knuckle. After the skin and fascia have been cut and are retracted, the extensor tendon and the capsule are divided, and as much of the capsule as possible is saved. The flexor tendons are divided and sutured to their sheaths, the digital arteries tied, and the capsule is sutured over the bone. The wound is closed by suturing the edges in an anteroposterior direction so that the scar forms a line leading from the back of the hand over the head of the metacarpal bone to the palmar surface. The flap

method can be used here also, particularly in the thumb, the index and little fingers, but the oval or racket method is best in the middle and ring fingers. If it is desired to make the hand smaller, the head of the matacarpal bone may be excised, but this decreases the strength of the hand.

Amputation or disarticulation of several fingers with a portion or all of the metacarpal bones may be done by a circular or by an oval incision. Flaps may be made or the oval incision may be converted into a racket incision by the addition of a single longitudinal cut. Amputation of a single finger with the corresponding metacarpal bone is done by a circular or oval incision around the base of the finger through the webs and a straight incision over the back of the metacarpal bone throughout its length. If the ring or the middle finger is removed, disarticulation of the corresponding metacarpal bone often adds symmetry to the hand, but at the expense of strength. Fingers may be transplanted, the little finger to the position of the ring finger, the index finger to that of the middle finger.




Fig. 903.—*A*, Amputation of last phalanx by palmar flap, *B*, amputation of thumb at the proximal joint by long palmar flap, *C*, disarticulation of first metacarpal bone and thumb by oval method

## HAND

In amputations about the hand, every effort must be made to preserve as much of the hand, and particularly of the fingers, as possible, but to leave one finger when the tendons are destroyed is doubtful wisdom, for it becomes ankylosed, and better service may often be obtained by providing a hook or some similar device that can be attached to the end of an artificial arm

Orr states that, as a rule, an amputation through the wrist is undesirable, since it is difficult to fit an artificial hand, and even when it is fitted, the apparatus projects beyond the length of the normal hand and produces an awkward appearance. However, amputation of disarticulation should be done at the wrist joint rather

than through the lower third of the forearm when the condition of the soft parts permits. The resulting stump is superior, owing to the preservation of the distal radioulnar joint and the insertion of the supinator longus muscle, which preserve the movements of pronation and supination; also, the styloid processes provide good support for a prosthetic appliance The uncomfortable above-elbow cuff is eliminated. Flexion and extension of the wrist in amputation of the wrist is preserved. It is true that the stump may not be good and it is with difficulty that a prosthesis is fitted. A satisfactory stump requires a palmar flap, the preservation of the radioulnar joint, and satisfactory sensation and blood supply to the stump.

When a palmar flap is to be used, a curved incision begins about 1.25 cm. below the styloid process of the ulna. The incision on the back of the wrist is curved slightly upward so that the palmar flap covers the whole stump. The dorsal incision is carried down to the bone, and the tissues are dissected as far as the joint. The long tendons are divided at the upper level of the incision and allowed to retract. The flexors and extensors of the wrist are reattached to the most distal convenient point in the bone that is in line with their insertion. After disarticulation of the joint is completed and the tendons are sutured, the flaps are approximated with interrupted sutures of fine silk.

If it is imposible to secure a long palmar flap at the wrist, palmar and dorsal flaps of approximately equal length may be used. Great care should be taken to see that they are not too narrow. Occasionally it may be necessary to fashion flaps from the sides, but this is not desirable. However, the only satisfactory method is to cover the stump with palmar skin by using a long anterior and a short posterior flap

## FOREARM

In the forearm the site of choice for amputation from the standpoint of fitting an artificial apparatus is at the junction of the lower and middle thirds. Amputation at any point distal to this junction is poor from both the prosthetic and the stump standpoints. Amputation at any point above this to within about 7.5 cm. of the elbow will provide a usable stump. Very short forearm stumps are hard to fit, since the biceps muscle pushes off the bucket of the artificial limb when the elbow is flexed.

Amputation of the forearm can usually be done satisfactorily either by the circular method or by anterior and posterior flaps, the circular or cuff method being very satisfactory (Fig. 904). The muscles should be cut in two layers, superficial and deep. Particular care must be taken to see that the median, radial, and ulnar nerves are identified. They are drawn gently downward and sectioned with a sharp knife, as high as possible, so that they will not form attachments to the scar of the stump.

In any amputation about the arm or forearm, as much tissue as possible should be saved and every effort made to provide a stump as nearly ideal as possible. This means that the scar should be linear, should not be adherent to the bone, and should not have too much redundant tissue. The stump is valuable for leverage and should be as long as possible, but when the bones of the carpus are seriously injured, it is better to amputate at the wrist joint than through the carpus or at the carpometacarpal junction. Pronation and supination should be preserved whenever possible.

If the bones in the stump of the forearm measure less than 7.5 cm. from the tip of the olecranon, it will be difficult or impossible to adjust a satisfactory artificial arm, but, if an artificial arm is not anticipated, even so short a stump is of considerable service. Although the possibility of the use of an artificial arm must always be borne in mind in amputating the arm or forearm, most patients do not wear them (Fig. 905); however, after amputation of a lower extremity, an artificial leg is always desirable. It is exceedingly important, if possible, to retain the elbow joint even though the amputation is above the ideal level. The highest level of usefulness is 4 cm. below the biceps insertion. The stump may be lengthened by a bone graft or the biceps tendon may be sectioned, as this increases the functional length.

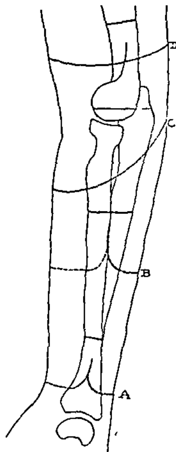



Fig. 904.—Lines of incision for amputation of forearm and lower third of arm: *A*, by cuff method, *B*, by equal flaps, *C*, by oblique circular method, *D*, by circular method.

An amputation through the elbow joint is not desirable except for temporary purposes or under unusual conditions, as it produces a bulky stump which makes it very difficult to apply a convenient and useful artificial limb. When such an amputation is indicated, it may be done by any method that permits satisfactory covering of the end of the bone, but it must be remembered that the end of the humerus requires a large flap of skin to cover it well Probably the best method of amputation at the elbow is the elliptical or oblique method, though long posterior and short anterior flaps make a satisfactory stump, as the skin on the back of the forearm is thicker than that on the front of the forearm The necessities of the occasion, however, may demand a longer flap from the front of the forearm or external and internal flaps The important anatomic structures about the elbow which must be kept in mind are the larger arteries—the brachial with its large anastomotic

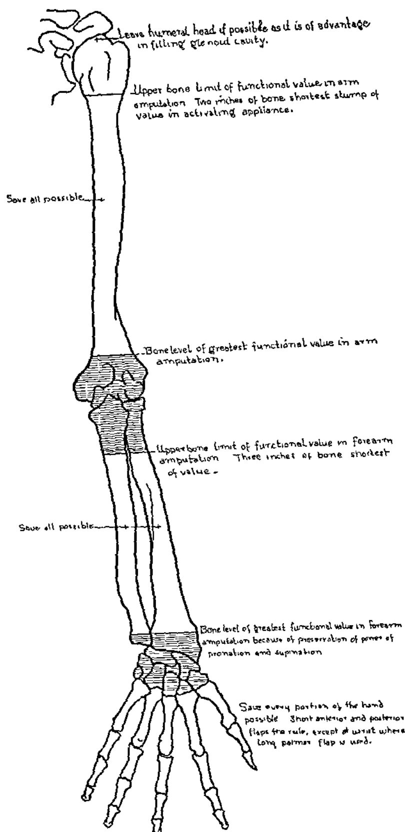



Fig. 905.—Locations of choice for amputation in the upper extremity. (From Military Surgeon.)

branches, the radial with its recurrent branch, and the ulnar with its recurrent branches—and the ulnar, radial, and median nerves, the last of which lies medial to the brachial artery, anterior to the elbow joint.

When the amputation is to be done by the elliptical method, it is begun by marking out the skin incision, the upper limit being anterior and opposite the condyles (Fig. 906). The lower limit is posterior and one and a half diameters or one-half of the circumference of the arm below the condyles. The skin and fascia are cut through and, when retraction has occurred, the muscles are divided on the line of the retracted flap. The posterior muscles are dissected free from the bone, and when the dissection has reached the ligaments of the joint, the ligaments are divided and left attached to the muscle. Disarticulation is completed by an incision in front, and the posterior musculotendinous flap is turned forward and sutured over the articular surface. The skin is approximated, the convex lower end of the flap being fitted into the concave upper part of the ellipse.

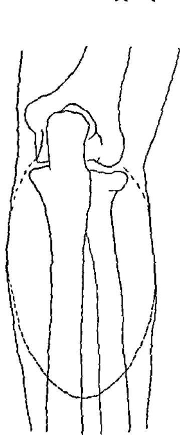


Fig. 906.

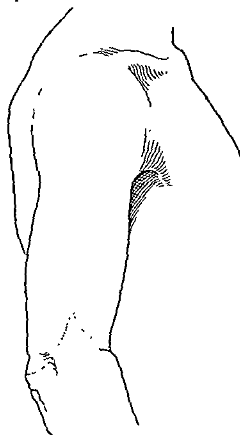


Fig. 907.

Fig. 906.—Lines of incision for amputation at elbow by posterior elliptical flap.
Fig. 907.—Amputation through lower portion of humerus.

If the disarticulation is done by long posterior and short anterior flaps, the incisions are marked out, beginning about 2.5 cm below the condyles. The anterior flap should not be more than one-half the length of the posterior one. The rest of the operation is carried out as above described.

## UPPER ARM

Amputation of the arm may be done at any level, but, if an artificial limb is to be employed, the stump should be not longer than would result from division of



Fig. 908.—Tendinoplastic amputation of lower third of arm. (Redrawn from Nelson's Loose Leaf Living Surgery.)

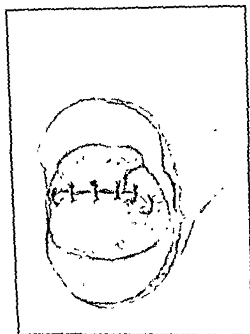


Fig. 909.

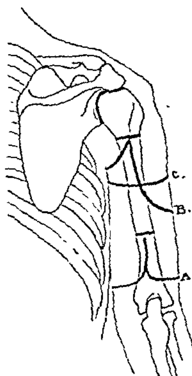



Fig. 910.

Fig. 909.—Suture of triceps tendon. (After P. D. Wilson: Nelson's Loose Leaf Living Surgery.)

Fig. 910.—Lines of incision for amputation of the arm: *A*, by lateral flaps; *B*, by long external flap, C, by circular method.

the bone about 2.5 cm. above the condyles (Fig. 907). This not only gives the best leverage for an artificial arm and places the artificial elbow at the proper level, but also permits the broad *triceps tendon to cover the bone end,* a most important consideration (Fig. 908). This tendon is left sufficiently long to be sutured across the end of the bone to the biceps tendon anteriorly and to the fascia laterally (Fig. 909). *A long posterior skin flap should be used when possible.* Amputation at the junction of the middle and lower thirds of the arm may be done very satisfactorily by the circular method, but any form or shape of flap can be used that suits the emergencies of the situation (*Fig. 910*).

The middle third of the arm is the region for which a circular amputation is peculiarly suited, as it often enables the bone to be divided at the lowest possible point. Amputation, however, may be done with flaps that are equal or unequal. At this level, it is impossible to use the tendinoplastic method of closure, but sufficient fascia should be saved to permit its being sutured over the end of the bone. This will give a good covering and will also prevent undue retraction of the muscles

Amputation of the upper third of the arm is best done by a single external flap, though anterior and posterior flaps may be used. If the external flap method is adopted, the vertical incisions are begun at opposite points, anterior and posterior, about 2.5 cm. below the level at which the bone is to be divided. These incisions pass downward and curve to a point on the outer side of the arm so that the flap is equal in length to the diameter of the limb. The upper ends of the vertical incisions are connected across the inner surface of the arm. It is best to save the tendon of the major pectoral muscle, and, if the bone is to be divided above its insertion, the insertion of this tendon is stripped up, left in the flap, and sutured to structures on the outer side or front of the stump. The tendons of the latissiums dorsi and teres major muscles are also preserved, if possible. The transverse incision on the inner side of the arm is made sufficiently low to protect the circumflex nerve and the posterior circumflex artery. After the muscles have been divided to the bone, they are retracted and a malleable retractor is placed internally in order to protect the vessels while the bone is divided. According to Rose, a short arm stump may be lengthened by dividing a portion of the pectoralis major and teres minor tendons and thus raising the anterior axillary fold.

At least 7.5 cm. of the shaft of the humerus, that is, about 5 cm. below the anterior axillary fold, should be saved, as it is difficult to fit a shorter stump with a satisfactory appliance If it is necessary to amputate less than 7.5 cm from the shoulder joint, Orr states that it is better to leave the head of the humerus in its socket to prevent the flattening of the shoulder, which otherwise may be apparent through the clothing. On the other hand, if an artificial arm is to be worn, it will fit better if the head of the humerus is disarticulated.

## SHOULDER

Amputation or disarticulation at the shoulder joint can be done by the external racket incision of Larrey, the anterior racket incision of Spence, or a U-shaped flap. The most important problem in these operations is the control of hemorrhage A tourniquet will slip after disarticulation at the shoulder unless it is fastened by some special method, so preliminary ligation of the subclavian artery is advisable If this is contraindicated and the metal pins of Wyeth are used to hold the tourni-

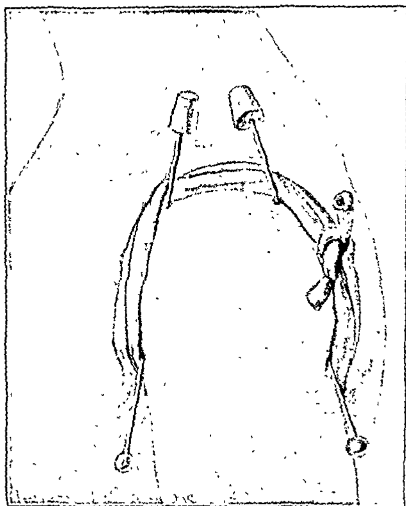


Fig. 911.—Wyeth's method of hemostasis for amputation at shoulder.

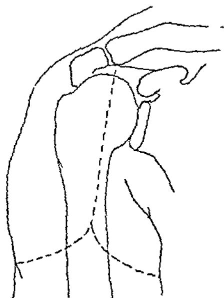


*Fig 912.—Lines of incision for amputation of shoulder by anterior racket method of Spence.*

the bone about 2.5 cm. above the condyles (Fig. 907). This not only gives the best leverage for an artificial arm and places the artificial elbow at the proper level, but also permits the *broad triceps tendon to cover the bone end, a most important consideration* (Fig. 908). This tendon is left sufficiently long to be sutured across the end of the bone to the biceps tendon anteriorly and to the fascia laterally (Fig. 909). A long posterior skin flap should be used when possible. Amputation at the junction of the middle and lower thirds of the arm may be done very satisfactorily by the circular method, but any form or shape of flap can be used that suits the emergencies of the situation (Fig. 910).

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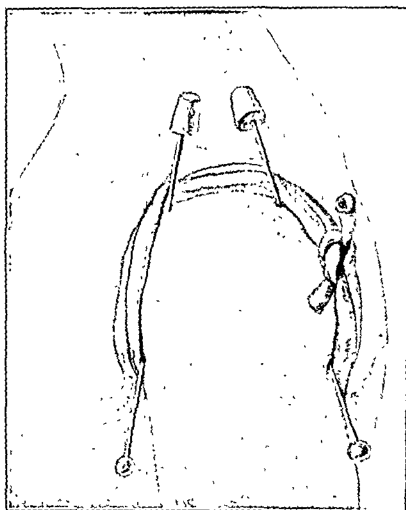


Fig. 911.—Wyeth's method of hemostasis for amputation at shoulder.

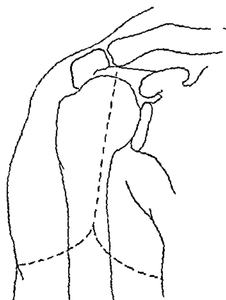


Fig 912—Lines of incision for amputation of shoulder by anterior racket method of Spence.

quet in position, the anterior pin enters at the middle of the lower margin of the anterior axillary fold and emerges about 2.5 cm. internal to the tip of the acromion process. The posterior pin enters at a corresponding point on the posterior axillary fold and emerges posterior to the first pin and about the same distance internal to the tip of the acromion process. A large soft rubber tube is wrapped around the shoulder above the pins after their tips have been protected by cork to prevent injury to the operator's hand. The tube is wrapped around tightly four or five times and securely fastened by stout clamps; the ends are placed posteriorly so that they will be out of the way (Fig. 911). Wyeth pins are rarely used now.

If the external racket incision is to be used, it is begun just below and in front of the acromion and is carried down vertically on the outer surface of the arm for about 10 cm. where an oval incision is begun, which is carried around the arm, curving somewhat downward on the medial side. The oval incision is carried through only the skin and subcutaneous tissue at first. The anterior and then the posterior structures are divided down to the bone. The capsule of the joint is incised over the head of the bone, the arm is rotated outward, and the tendon of the subscapular muscle is divided. After this, the arm is rotated inward, and the supraspinatus, the infraspinatus, and the teres minor muscles are divided. The rest of the capsule of the joint and the ligaments are severed, as much of them as possible being saved for the flap. The axillary artery is doubly ligated with catgut and the nerves are treated in the usual manner. All vessels are clamped and tied, and the tourniquet is gradually loosened to see whether any bleeding vessels remain. The muscles and fascia are approximated by interrupted catgut sutures, and the skin is sutured with fine silk.

The anterior racket incision (Fig. 912), the one most often used, is begun by a vertical incision starting at the level of the upper portion of the head of the humerus between the coracoid and the acromion processes and passing down between the deltoid and the major pectoral muscles to the insertion of the major pectoral, which is divided. Here the incision branches, one limb passing downward and inward and the other downward and outward, forming an oblique incision which surrounds the arm about on a level with the insertion of the deltoid muscle. The vertical part of the incision exposes the joint and bone. The muscles are cut on a level with the retracted skin and fascia, and the inner portion of the flap is dissected up The outer portion of the incision, which divides the deltoid muscle at its insertion, is then carried down to the bone. Injury of the circumflex nerve to the deltoid is avoided by making the outer limb of the incision level with the insertion of this muscle. The muscles are separated from the bone by periosteal elevators, chiefly through the vertical incision, by rotating the arm first inward and then outward. The muscles inserted near the head of the humerus are divided and as much as possible of the capsule of the joint is preserved to cover the glenoid cavity. After the vessels are ligated and the nerves treated, the stumps of the muscles are sutured together to protect the acromion process and the glenoid cavity

Amputation through the shoulder joint may also be done by medial or lateral flaps or by other combinations that may appear advisable under the circumstanes. Crile advised an incision along the outer margin of the sternocleidomastoid muscle just above the clavicle, dividing the deep fascia, retracting the omohyoid downward and the trapezius muscle backward, and exposing the trunks of the brachial plexus and the subclavian artery. The nerve trunks are injected with procaine solution

A rubber-shod clamp is applied to the subclavian artery. Amputation is then completed without a tourniquet, according to any of the methods that may seem desirable.

## FOREQUARTER

Amputation of the complete upper extremity, or interscapulothoracic amputation, is occasionally indicated in some types of malignant tumors. The method of LeConte is satisfactory. The incision is begun at the inner end of the clavicle and carried along the bone to its middle, then curved downward to the anterior axillary fold. The skin and superficial fascia are dissected up to expose the inner two-thirds of the clavicle, which is disjointed at its attachment to the sternum, and the insertion of the sternocleidomastoid muscle is divided. The clavicular portion of the pectoralis major is separated bluntly from the costal portion of the muscle as far as the anterior axillary fold, the clavicle is pulled upward and forward, and the subclavious muscle, which is put on a stretch, is severed at the first rib. The pectoralis minor is next divided and its upper portion is reflected up with the clavicle, to expose fully the axilla and its contents. The sheath of the vessels is opened, the vein separated from the artery, and two ligatures are passed around the artery. The arm is held up to empty the veins as much as possible, and two ligatures are then placed on the axillary vein. If the cephalic vein enters the axillary vein above the point of ligature, it will also require ligation. The vessels and the cords of the brachial plexus are divided and the costal portion of the pectoralis major is severed, thus completing the division of the anterior attachments of the arm. The posterior incision is carried from some point on the anterior incision, as near the tumor as is thought safe, backward and downward to the lower angle of the scapula and then to the posterior axillary fold. The skin and fascia are dissected for a short distance, the trapezius muscle is divided, and the transverse cervical and the posterior scapular arteries are clamped, divided, and ligated. The muscles attached to the inner border of the scapula are divided close to the bone, the serratus magnus muscle is severed, and the latissimus dorsi is divided at the posterior axillary fold, thus leaving the arm attached to the body only by the skin of the axilla. If there is enough flap to cover the wound, the anterior and posterior incisions may be sutured over the axilla, but, if more skin is needed, before completing the amputation, a flap may be fashioned from the undersurface of the arm with its base at the axilla. The skin and superficial fascia are united in the usual manner and a small rolled rubber tissue drain is inserted at the lowest angle of the wound.

Crile advises resection of the inner half of the clavicle to expose the subclavian vessels and the brachial plexus. He then injects the brachial plexus with procaine solution, ligates the subclavian artery and then the subclavian vein. The rest of the operation is completed according to the method of LeConte.

The chief advantage of both of these methods is that they allow *early exposure* of the subclavian vessels and ligation of the artery before the vein, with considerable saving of blood

## CINEPLASTIC OPERATIONS

A cineplastic amputation creates a stump, which, by some special provision, is capable of individualized movement, or movements, apart from the general *motion* of the stump. The prosthesis is activated by harnessing the local muscle by means of

special surgery. Vanghetti, an Italian practitioner, was the first to suggest such *motor stumps, and the Italian surgeon, Ceci, the first to demonstrate their feasibility* by operation. This method of amputation opens a large field for surgical ingenuity, but its value is not yet fully appreciated. Bickham claimed that many ordinary amputation stumps can be made more useful by cineplastic repair, and this is in keeping with the results obtained by Kessler, whose method will be described in some detail. One of the reasons that this operation is not used more frequently is the difficulty in obtaining a satisfactory prosthesis.

Cineplastic amputation of the forearm with a double motor stump may be done by the following method. The *circular incision through the skin and subcutaneous* fascia is made as low on the forearm as possible, and the muscles and tendons are divided to the bone at a level with the retracted skin. Vertical incisions are then *made on the radial and ulnar sides down to the bones*, extending up from the circular skin incision about 15 cm. In this manner, anterior and posterior flaps are formed and are dissected up so that each flap contains all the tendons and muscles between the skin and the bones. The radius and ulna are divided at the upper end of the vertical incisions. One flap contains the extensor tendons and the other the flexor tendons The skin and fascia are freed from the muscles of the flap for about half its length, the tendons in each flap are divided into two groups, and each group is sewed together to make a loop. The skin of each flap is then sutured over *the bundles of tendons, and a longitudinal incision is made in the skin over the loop* of the tendons and in the folded-over skin opposite the first incision. These buttonhole incisions are about 2.5 cm. long.

A similar procedure is carried out with each flap so that when *completed the* anterior flap contains the flexor tendons and the posterior contains the extensor tendons. In each flap the long tendons, which have been sewed together in a loop, surround the perforation made in the skin. Rubber tubes or strips of gauze are placed through these perforations (Fig 913). No traction is applied for about ten or twelve days, when gradual traction is begun. After the stump has healed, early exercise and motion are begun to strengthen the muscles and to avoid permanent contractures and adherent scars. The patient can voluntarily move either the anterior or the posterior flap An apparatus fitted over the forearm can be worked by cords running from the flaps to the fingers of the artificial hand.

A motor stump can also be constructed by having the group of anterior flexor tendons attached to a piece of bone, as to the end of the radius, and the posterior or extensor tendons to the end of the ulna. About 5 cm of the bone is resected, just proximal to the end, leaving the disconnected ends of the radius and ulna. A slight constriction is placed on the stump above the ends of the bones, and when healing takes place a ring is fitted which is capable of transmitting motion to an appliance connected with it (Fig. 914). This works on the same principle as the perforated cineplastic flaps.

The Krukenberg operation differs from the above-mentioned methods of cineplastic amputation by making two digits, one containing the radius and the other *the ulna The motor power* for the radius comes from the flexor carpi radialis and the radial half of the flexor sublimis and the extensors. The ulnar half utilizes the triceps and the ulnar portion of the flexor sublimis One of the main advantages

of this procedure is that the patient has the sensation of touch. The two segments function as pincers. This is an unsightly amputation but is of use in the bilateral blind amputee.

Cineplastic amputations may also be done above the elbow by carrying out the same principles described for the forearm.

A cineplastic amputation should not be attempted in the presence of infection, but all of the tendons and muscles of the stump should be saved and, after healing has occurred, a cineplastic revision of the stump may be done.

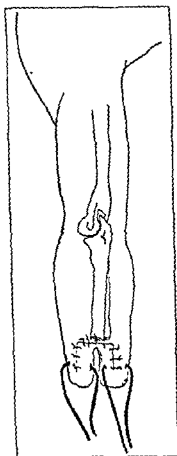


Fig. 913.

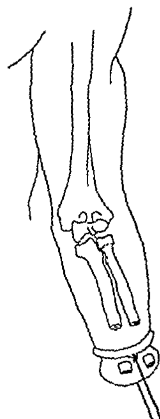


Fig. 914.

Fig 913.— Vanghetti's cineplastic amputation through the forearm, providing a double loop motor stump. Drawing shows suture lines and rubber tubes temporarily distending the "buttonholes."

Fig. 914 —De Francesco's cineplastic amputation through the forearm, providing an osseomuscular motor stump Ring and cords are in position ready for application of the artificial limb.

Kessler reported the results obtained in 78 patients upon whom he had done cineplastic revision of ordinary amputation stumps involving the forearm and arm. (Fig 915.) The procedure is simple and the results are remarkably good. He states that it has not been necessary in any instance to revise the stump other than to prepare a satisfactory motor. He stresses the importance of careful examination before the patient is anesthetized so that the location of muscles satisfactory for use as motors may be accurately determined by having the patient voluntarily contract them. When the site for the motor or motors is decided upon, the skin should be carefuly marked, so that the proper muscles will be employed. The flexor sublimis

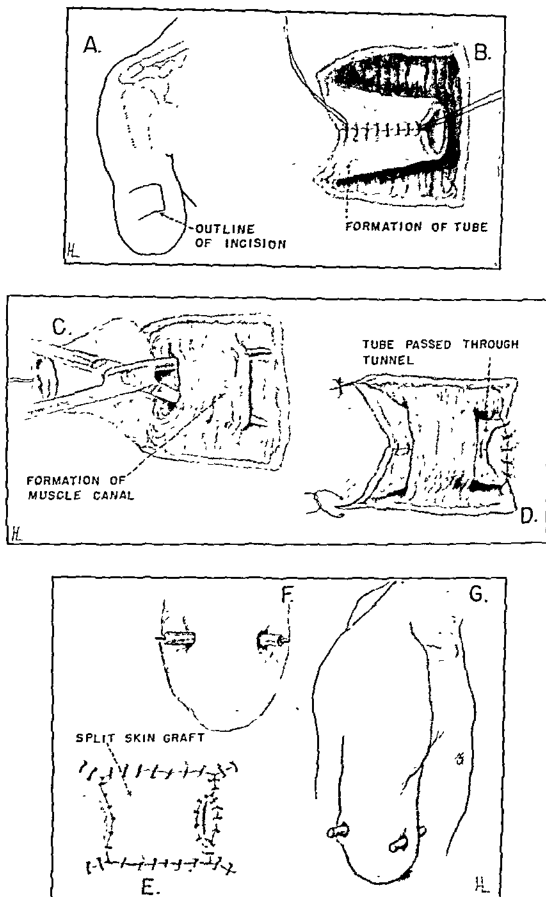



Fig 915 —Cineplastic amputation *A*, Outline of incision *B*, Skin inverted to form tube. *C*, Canal through muscle. *D*, Tube sutured after passing through muscle tunnel *E*, Split thickness skin graft *F*, Pegs in place in above-elbow amputation *G*, Completed, with both pegs in place

muscle is used on the anterior side and the extensor communis on the posterior side in the forearm. In the arm the biceps muscle is used for the anterior side and the triceps for the posterior side. The pectoral muscle may be used for the short above-elbow stump.

At the site selected a three-sided skin and subcutaneous tissue flap is turned up, with each side 3.75 cm. long. The flap is converted into a tube with the skin side in. The end of the tube is fastened together by a silk suture which is left long for traction. The remainder of the tube is formed by approximating the edges with subcuticular sutures of fine catgut. Two parallel incisions are made in the muscle and an instrument is passed through the muscle to form a canal. A tube is drawn through this canal by traction on a silk suture, care being used to avoid twisting the base of the tube flap. The edge of the tube is sutured to the skin and the raw surface resulting from elevation of the skin flap is covered This may occasionally be done by approximating the skin margins but often there is too much tension. If excessive skin tension results when an attempt is made to approximate the adjacent edges of the skin, it is better to remove the approximating sutures and cover the raw surface by a Thiersch graft. A gauze wick is inserted through the canal. Motor pegs are inserted in about three weeks and the stump is ready for prosthesis in about six weeks.

Kessler emphasizes the following points in connection with this procedure: the selection of psychologically suitable patients; and the careful placing of the motor canal, which should always be in the muscle belly and not in the tendon.

This simple procedure seems to offer much for the rehabilitation of those individuals who have had the misfortune to lose either one or both arms.

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# CHAPTER 69

# AMPUTATIONS OF THE LOWER EXTREMITIES

M. Josiah Hoover, Jr.

The same general principles that have been emphasized in amputations of the upper extremities apply also to amputations of the lower extremities The problems are slightly different, however, because of the necessity of weight-bearing on the stump of the leg.

Experience during and after both World War I and World War II threw much light upon the problems of amputation, particularly concerning the most efficient stump. Starr emphasized the desirability of obtaining an ideal stump and defined it as one that is best suited for an artificial appliance for that portion of the extremity. It should have a linear scar, be free from puckering or infolding of the skin, and have sufficient flap but no redundancy. There should be a pad of fat and subcutaneous tissue over the end of the bone, but it should not be adherent. The joint next above the amputation must have a full range of motion. Such a stump is not easily obtained, but the ideal should be kept in mind and an effort made to approach it when amputation is necessary (Fig. 916).

Amputation of the toes with a plantar flap causes little disability. The Lisfranc tarsometatarsal amputation also gives good results, especially if the attachments of the peroneal and tibial muscles are left intact. The midtarsal or Chopart amputation, however, results in an unbalanced foot, with elevation of the heel, which cannot be properly fitted with either an artificial foot or a boot, so this method of amputation should not be used. The Syme operation, which gives far better results, should supplant it.

The most favorable site for amputation through the leg is the lower part of the middle third with a stump 20 to 25 cm long Below this point the stump is not so satisfactory for weight-bearing or the fitting of an artificial appliance; and the flaps are usually poorly nourished and tend to break down Above this point leverage is diminished So-called "kneeling" stumps are no longer advisable. After an amputation below the knee, the leg should be held in extension, but the knee should be kept mobile by active and passive motion.

In traumatic cases with considerable shock or infection, amputation through the knee joint may be the safest procedure, but reamputation is usually advisable before fitting an artificial limb. According to Lockwood, amputation at or above the level of the knee joint is indicated in senile gangrene, for the site of arterial obstruction is usually at the bifurcation of the popliteal artery. Amputation about 7.5 cm above the lower articular surface of the femur or 5 cm. from the most promi-

nent part of the condyles gives the best stump for an artificial limb (Fig. 916). Above this point all the length possible should be saved, for the longer the stump the better the leverage. A stump shorter than 12.5 cm. from the perineum is diffi-

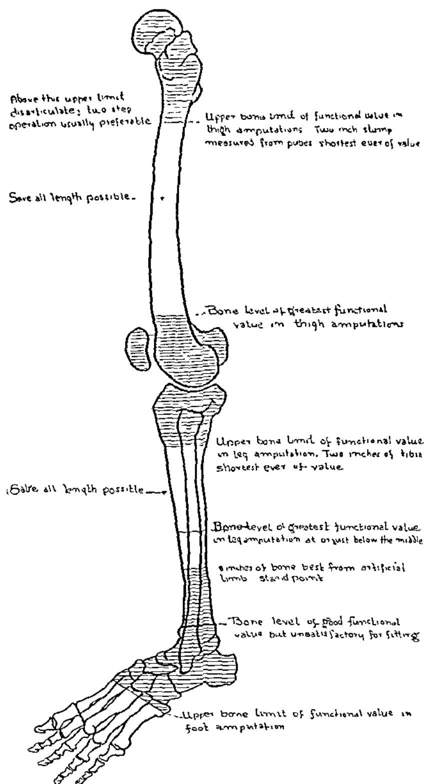



Fig 916.—Levels of election for amputations in the lower extremity. (From Military Surgeon)

cult to fit with a thigh bucket. After amputation at or above the lesser trochanter, it is possible to fit a "tilting table," an appliance which has an automatic lock at both the hip and the knee.

## TOES

Amputation of the toes may be done in the same general way as amputatic the fingers (Fig. 917), as the arrangement of the tendons is much the same. great toe is exceedingly important, more so than any of the others. The distal of the first metatarsal bone should be preserved whenever possible, as it consti the anterior pedestal of the plantar arch. It is important in toe amputations the scar fall on the dorsum of the foot and never on the plantar surface. S the toes are short, disarticulation is usually done. The long plantar flap pro tough skin accustomed to weight-bearing. The length of the plantar flap shoul one and a half times the diameter of the toe, but if a full plantar flap cannc

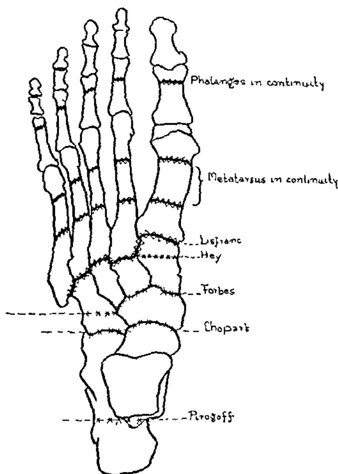



Fig. 917.—Skeletal lines of incision in several of the well-known foot amputations. (Redr from Orr )

obtained, a racket or oval incision may be used. Amputation or disarticulatior the great toe at the metatarsophalangeal joint is best done by a type of racket ir sion that begins over the middle of the joint on the dorsum of the foot and is carr along the junction of the upper and medial sides of the great toe to the distal ( of the first phalanx. From this point the incision curves around the medial surf of the toe, then the undersurface, and finally across the outer surface back to point of beginning. It should be remembered, in speaking of the medial or late portion of the toe in an anatomic sense, that the lateral portion is that nearest little toe. The flexor and extensor tendons are divided and allowed to retract. T joint is opened on the dorsum and the capsular ligament divided close to the phala

in order to leave as much as possible to cover the end of the bone. If this type of operation is not feasible on account of the injured tissue, a long plantar flap serves an excellent purpose. Any of the other toes may be disarticulated at the metatarsophalangeal joint and if a long plantar flap cannot be secured, the racket incision gives good results.

Amputation of the second toe may be carried out through the distal phalanx without any great disturbance to the other toes. However, hallux valgus of a marked degree results almost always when the second toe is amputated at the proximal or middle phalanx. The pressure of the shoe and the adductor hallucis tendon pull the great toe into this position. Running and rapid gait are impaired. This toe should not be amputated unless orthopedic measures for correction are absolutely impractical, and as much length as possible should be saved. A plantar flap one and one-half times the diameter of the bone is used.

If it is necessary to amputate four toes, the remaining one, if not the great toe, should also be amputated, for when only one is left it is apt to become stiff and sensitive.

In disease of a metatarsal bone the entire bone with the corresponding toe can be removed by a long incision along the dorsal surface of the toe in conjunction with an oval incision surrounding it, the latter being so placed as to form a long plantar flap. In making the dorsal incision it must be remembered that the tarsometatarsal joint corresponding to the second toe is slightly farther back than the others. The extensor tendon is divided through the proximal portion of the incision except in the great or little toe, where the tendons are left sufficiently long to be sutured together over the end of the bone. In the other toes the tendons are of no great importance when the metatarsal bone is to be removed If the bone is to be divided and not disarticulated, a wire saw should be used, care being taken to protect the soft tissues. Amputation or disarticulation of two or more toes with their metatarsal bones can be done with a racket incision that is merely an enlargement of the type of incision used for amputation or disarticulation of a single toe with its metatarsal bone

Amputations through the metatarsal bones cause loss of balance and support by removal of the anterior weight-bearing pillar. Even the loss of one metatarsal results in considerably lessened stability in the foot. The skin underlying the heads should be preserved, for weight-bearing requires a thick plantar skin with adequate sensation. All useful bone length should be preserved Partial forefoot amputation gives a better functional result than transmetatarsal amputation. A good walking foot may be obtained when the amputation passes through all the metatarsals An incision is made so that a long plantar flap and a short dorsal flap are formed. The tendons are sectioned so that they will retract above the wound edge. The bone is sectioned parallel to the tarsometatarsal joint. The nerves are sectioned so as to fall back beyond the sectioned bone. After closure a plaster of Paris cast is applied and worn for several weeks.

Amputation at the tarsometatarsal joint, or Lisfranc's amputation, may give good results (Fig 918), but it is frequently difficult to obtain a sufficiently long plantar flap for this operation. With the foot in plantar flexion the incision is begun at a point just posterior to the base of the metatarsal bone of the little toe and is carried in a slightly curved direction distally along the lateral side of the foot for

about 2.5 cm. It is then curved across the dorsum of the foot about 1.25 cm. distal to the tarsometatarsal joints and is carried backward to the medial side of the foot a short distance proximal to the base of the metatarsal bone of the great toe. Especial care should be taken to protect the insertions of the peroneus and tibialis anticus muscles on the lateral and medial sides of the foot. The extensor tendons are divided and the incision is carried down to the joint, while the foot is strongly plantar flexed to facilitate exposure of the joint. The dorsal flap contains as much of the subcutaneous tissue as possible and is dissected just proximal to the tarsometatarsal joint. The incision for the plantar flap begins at the point of origin of the dorsal incision, that is, just posterior to the base of the fifth metatarsal bone, and is carried forward and slightly medially, then curved across the plantar surface about opposite the distal ends of the metatarsal bones to the medial side of the foot, and ends just proximal to the first metatarsal. The plantar flap should be somewhat longer on the medial side than on the lateral because there is more bony surface to be covered in this region. The incision for the flap is carried down to the muscles for the distal 3.75 or 5 cm. and then down to the bone, care being taken to protect the plantar arteries.

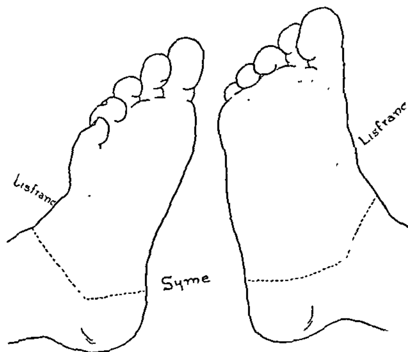



Fig 918.—Lines of incision for Lisfranc and Syme amputations of foot.

This flap, which should include all of the soft parts in its proximal portion, is dissected up to a point just proximal to the tarsometatarsal joint. The joint is disarticulated with a strong, narrow-bladed knife, by beginning between the first metatarsal bone and the internal cuneiform. The knife is then inserted between the first and second metatarsals, carried back to the base of the second metatarsal, and a similar incision is made between the second and third metatarsals. Then the joint between the second metatarsal and the middle cuneiform is severed by a deep transverse incision with a strong narrow knife The rest of the metatarsal bones are separated from the tarsus by opening the dorsal surface of the joint. If there is difficulty in disarticulating the second metatarsal because of its deep insertion, its base may be divided by a saw. This gives a satisfactory stump. It is better to do this

than to adopt the suggestion of Hey, who advised sawing off a part of the internal cuneiform bone, because the insertion of the tibialis anticus may be sufficiently affected to jeopardize the usefulness of the foot. The arteries to be tied are the dorsal interosseous, the communicating branches of the dorsalis pedis, the four digital arteries in the plantar flap, the internal plantar, and sometimes the external plantar. The flexor and extensor tendons are sewed together over the bone in order to give better control of the stump, and the plantar and dorsal skin flaps are approximated. If there is too great a tendency toward plantar flexion of the stump, the tendo achillis should be lengthened.

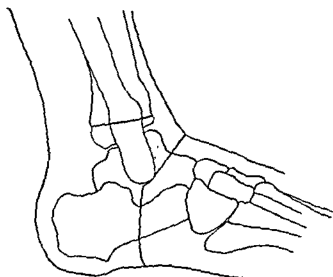


Fig. 919

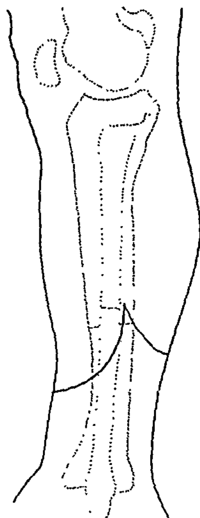


Fig. 920.

Fig. 919.—Lines of incision for amputation of Syme at the ankle.
Fig. 920.—Long anterior flap in amputation of lower leg.

The operation of Chopart, or disarticulation of the foot through the midtarsus, should be discarded, as the insertions of the anterior tendons are cut away and there is nothing to oppose the action of the tendo achillis, and this results in an unbalanced foot. The Pirogoff amputation, in which the posterior portion of the os calcis is fixed to the lower end of the tibia after the malleoli have been sawed off, has not given satisfactory results and is a somewhat difficult procedure.

The Syme operation is the most useful one in the region of the ankle joint and is indicated when amputation cannot be done at the tarsometatarsal joint. In the presence of vascular disease it is contraindicated. In this operation an incision is

made to the bone from the tip of the external malleolus down, then across the sole of the foot, and up to a point about 1.25 cm. below the internal malleolus, the center of the plantar incision being curved very slightly toward the heel. The upper ends of this incision are then joined by a straight incision carried across the front of the ankle joint (Fig. 919). The foot is bent strongly downward, the ankle joint is opened from the front, and the lateral ligaments are divided. Care should be taken in dissecting the soft parts on the inner side of the ankle to avoid injury to the posterior tibial artery and its branches, as this is the most important source of blood supply to the flaps. As the joint is opened farther, the tendo achillis and the heel flap are freed from the os calcis from above downward, the dissection being kept as close to the bone as possible. The flaps are retracted and both malleoli, together with a very thin slice of the joint surface of the tibia, are removed with a saw. It is essential that the bones be divided at a right angle to the vertical axis of the leg The posterior tendons should be sutured to the tendo achillis and the anterior tendons attached to the periosteum. The posterior or heel flap is brought forward and sutured so that it will cover the weight-bearing portion of the stump.

## LOWER LEG

If the Syme operation cannot be done, the next site for an amputation should be the lower portion of the middle third of the leg because of the difficulty of fitting an artificial leg or foot when the amputation is closer to the ankle joint. This may be done by flaps or by the oval method. Long anterior and short posterior flaps give the best weight-bearing stump (Fig. 920). If a long posterior flap has to be taken, it should be more from the posterointernal aspect than from the posterior surface. The level of division of the bone is first marked out on the skin, and then a broad anterior flap, about four-fifths as long as the diameter of the leg at the level of bone division, and a short posterior flap are made. These flaps are dissected up a short distance above the level of amputation and the fascia is divided at that level. The gastrocnemius tendon is severed sufficiently low to permit its being sutured over the end of the bone to the fascia anteriorly. The flaps are retracted above the level of the saw line, the bones are divided, and the sharp crest of the tibia is beveled. The fibula should be divided at least 3 cm. above the level of division of the tibia so that it will not be subjected to direct pressure. In amputations of the lower extremity the end of the stump does not bear weight, but the weight is carried on the metaphyseal flare of the tibia. The rounded, gently tapering stump is required Since the anterior stump surface comes in contact with the prosthesis, this surface is beveled so that there are no sharp projections. The nerves receive special care. The posterior tibial nerve and the superficial peroneal nerve are gently drawn down and sectioned so as to retract into their normal bed. (Fig 921.) The gastrocnemius fascia is brought forward and sutured across the bone to the fascia anteriorly and laterally, and the skin flaps are carefully approximated by interrupted mattress sutures. A drain is instilled in the lateral wound which is removed in forty-eight to seventy-two hours. A posterior plaster splint is applied and elevation of the leg is maintained for fourteen days.

In the middle third of the leg long posterior and short anterior flaps are satisfactory (Fig 922); but circular, oblique, or equilateral flaps may be used. In amputation at this level the fibula should be cut 1.25 to 2 5 cm shorter than the tibia.

In making the incision for amputation through the middle third of the leg by a long posterior and a short anterior flap, the posterior flap should be broad and U-shaped, its breadth being equal to one-half the circumference of the limb at the level of amputation and its length equal to at least one-third of the circumference. The

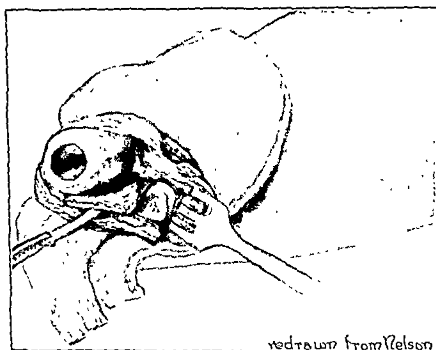



Fig. 921.—Tendinoplastic amputation of lower leg. (Redrawn from Nelson's Loose Leaf Living Surgery.)

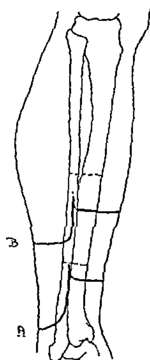



Fig. 922.—Lines of incision for amutation of leg: *A*, Farabeuf; *B*, Hey.

incision begins 2.5 cm. below the saw line, is carried down the leg just behind the medial border of the tibia, and then backward in a broad curve *on the back of the* leg The lateral incision passes downward just behind the fibula and back of the

peroneus muscles and curves onto the back of the leg, uniting with the medial incision. The anterior flap is one-third the length of the posterior one and is formed by joining the vertical incisions about the junction of their middle and upper thirds by an incision across the front of the leg, which curves slightly downward. This incision is made while the knee is flexed. These incisions are carried through the skin and fascia, and the posterior muscles are divided while the flaps are retracted. The vertical incisions are deepened and the anterior muscles are divided. The muscles are detached from the bone and the interosseous membrane, and this membrane is divided. The periosteum is removed either before or after the bone is sawed, and the crest of the tibia is beveled. The nerves are treated as usual and the aponeurosis over the muscles is carefully sutured over the ends of the bones for protection and also to prevent too great retraction of the muscles. The skin flaps are sutured in the usual way.

Proper shrinkage of the stump usually is obtained by correct bandaging. Adams has recomended neurectomy of the branches to the two heads of the gastrocnemius muscle, in order that atrophy may take place rapidly.

The knee in below-knee amputation is frequently allowed to flex. This flexion contracture of the knee follows prolonged flexion following operation. Surgical measures may be needed to excise the scar in cases that physical therapy will not correct. But these measures are seldom successful when capsulotomy and massive excision of scar tissue are required A reamputation or a bent-knee prosthesis may be required.

In amputations through the upper third of the leg, it is best to save as much bone as possible by making approximately equilateral flaps. The incision is extended upward on the outer side sufficiently far to permit excision of the entire fibula, if this is considered necessary. If the stump is unusually short, complete excision of the fibula gives a more stable stump and permits more satisfactory fitting of a prosthetic appliance. The rest of the operation is essentially the same as described for the middle third of the leg. If the stump is very short, it is wise to excise a considerable part of the bellies of the posterior muscles, along with the fibula, but the aponeurosis should be preserved and used to cover over the end of the bone. It is important not to injure the large vessels above the end of the stump, for this may interfere with its blood supply The nerve trunks and vessels are treated in the usual way and the flaps are sutured together over the ends of the bones with interrupted mattress sutures

Amputation through the middle or upper portion of the leg should be followed by the application of a posterior splint in order to prevent flexion of the stump.

In amputating through the thigh, as much stump as possible should be saved for better leverage, and, as a rule, long anterior and short posterior flaps are preferable. The retraction is greater on the posterior and inner parts of the thigh than elsewhere, so allowance must be made for this, and it should also be borne in mind that the lower the amputation the greater the retraction. The circular method of amputation in the thigh also gives fairly satisfactory results, though there is a greater tendency for the tissue to sag back than when a long anterior flap is used. This method of amputation should therefore be used only when there is not sufficient skin anteriorly for a long flap, or when, because of circulatory deficiency, it is thought that this type of amputation would be less likely to result in sloughing of the skin.

## THIGH

Amputations through the thigh are either end-bearing or ischium-bearing.

Disarticulation at the knee joint is illogical for a number of reasons, one of the most important being the difficulty of fitting a prosthetic appliance. It is altogether an undesirable procedure and should not be used except when done as an open operation because of an infection in or around the knee joint.

The Gritti-Stokes osteoplastic amputation would seem to be an almost ideal procedure and, when successful, probably gives as satisfactory a stump as any of the methods used in this region, but, unfortunately, it is frequently unsuccessful. It should never be done in the presence of infection, and the development of infection subsequent to operation is almost certain to result in failure. If the operation is done, it should be carried out in very much the same way as the tendinoplastic method through the supracondylar area, except that the bone is divided at a slightly lower level, and the patella, with its posterior surface removed by a saw, is sutured over the lower end of the femur.

Callander has devised a method of amputation through the lower part of the thigh for which he claims most of the advantages and few of the disadvantages of the Gritti-Stokes operation. The incision for the anterior flap begins on the medial side of the thigh three fingerbreadths above the most prominent part of the medial femoral condyle and is carried distally in the groove between the vastus medialis and sartorius muscles; then it sweeps distally and forward to cross the anterior surface of the tibia at the level of the anterior tuberosity. The thigh is rotated medially and the lateral portion of the incision is made It is started three fingerbreadths above the lateral femoral condyle and is carried distally in the groove between the tensor fascia lata tendon and the biceps femoris muscle, lying near the edge of the former structure. It is then carried downward and forward to connect with the medial incision over the tibial tuberosity.

The incision for the posterior flap begins at the posterior margin of the medial arm of the original incision at the level of the epicondyle of the femur and is carried distally and posteriorly across the posterior surface of the leg at a somewhat lower level than the tibial tubercle, then anteriorly and proximally to join the posterior border of the original incision at the level of the lateral epicondyle of the femur. The proximal portion of the medial incision is carried through the deep fascia, and the tendons of the sartorius, gracilis, semimembranosus, and semitendinosus muscles are freed to their insertion in the tibia and divided at that level. No muscle tissue is exposed. The tendon of the adductor magnus muscle is severed at its femoral insertion, to expose the neurovascular bundle. With the knee moderately flexed and the entire leg somewhat elevated, the vessels are easily dissected out and delivered at the level of the skin surface. The artery is doubly clamped, divided, and ligated. The vein is similarly treated If a tourniquet is not employed, a considerable amount of blood may be conserved by occluding the artery first. The nerves (tibial and peroneal) are injected with procaine, divided, and allowed to retract. The lateral incision is deepened through the posterior edge of the tensor fascia lata tendon as far distally as the head of the fibula, where the biceps tendon is divided.

The anterior incision is carried through the capsule of the knee joint and the quadriceps tendon is divided at its insertion into the tibial tubercle. The patella is

peroneus muscles and curves onto the back of the leg, uniting with the medial incision. The anterior flap is one-third the length of the posterior one and is formed by joining the vertical incisions about the junction of their middle and upper thirds by an incision across the front of the leg, which curves slightly downward. This incision is made while the knee is flexed. These incisions are carried through the skin and fascia, and the posterior muscles are divided while the flaps are retracted. The vertical incisions are deepened and the anterior muscles are divided. The muscles are detached from the bone and the interosseous membrane, and this membrane is divided. The periosteum is removed either before or after the bone is sawed, and the crest of the tibia is beveled. The nerves are treated as usual and the aponeurosis over the muscles is carefully sutured over the ends of the bones for protection and also to prevent too great retraction of the muscles. The skin flaps are sutured in the usual way.

Proper shrinkage of the stump usually is obtained by correct bandaging. Adams has recomended neurectomy of the branches to the two heads of the gastrocnemius muscle, in order that atrophy may take place rapidly.

The knee in below-knee amputation is frequently allowed to flex. This flexion contracture of the knee follows prolonged flexion following operation. Surgical measures may be needed to excise the scar in cases that physical therapy will not correct. But these measures are seldom successful when capsulotomy and massive excision of scar tissue are required. A reamputation or a bent-knee prosthesis may be required.

In amputations through the upper third of the leg, it is best to save as much bone as possible by making approximately equilateral flaps. The incision is extended upward on the outer side sufficiently far to permit excision of the entire fibula, if this is considered necessary. If the stump is unusually short, complete excision of the fibula gives a more stable stump and permits more satisfactory fitting of a prosthetic appliance. The rest of the operation is essentially the same as described for the middle third of the leg. If the stump is very short, it is wise to excise a considerable part of the bellies of the posterior muscles, along with the fibula, but the aponeurosis should be preserved and used to cover over the end of the bone. It is important not to injure the large vessels above the end of the stump, for this may interfere with its blood supply. The nerve trunks and vessels are treated in the usual way and the flaps are sutured together over the ends of the bones with interrupted mattress sutures.

Amputation through the middle or upper portion of the leg should be followed by the application of a posterior splint in order to prevent flexion of the stump.

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The anterior incision is carried through the capsule of the knee joint and the quadriceps tendon is divided at its insertion into the tibial tubercle. The patella is

carefully dissected out so that the depression which is left in the tendon will fit over the end of the femur. The synovial lining of the subquadriceps bursa is not removed, so that little raw area is exposed to possible infection. The femur is divided just proximal to the adductor tubercle and all sharp corners and angles are removed from the end of the bone. The tourniquet is removed and the flaps are inspected for bleeding vessels which are carefully ligated. The flaps are loosely approximated with a few interrupted sutures, if there is no obvious infection in the adjacent tissues. In the presence of active infection distal to the site of amputation, especially if anaerobic organisms are found, the wound may be left open or loosely packed.

The chief advantages of this operation are its simplicity, the lack of exposure of muscle tissue, and the long and otherwise satisfactory weight-bearing stump It does have a number of advantages over the Gritti-Stokes operation and also over the operation described in the following paragraph, but tendinoplastic amputation of the lower one-third of the thigh may be used at times when the blood supply of the leg would not permit the employment of the Callander operation.

The tendinoplastic method is the most consistently satisfactory amputation for the lower third of the thigh. When sufficient skin is available, the length of the anterior flap should be equal to one and one-half times the diameter of the thigh at the saw line. The incision begins at the level at which the femur is to be divided and about the middle of the medial surface of the thigh and curves down the medial side of the thigh, then forward in a broad curve over the upper anterior surface of the knee, and up the mid portion of the lateral side to a point about opposite its origin. The incision for the posterior flap begins at the upper end of this incision and is carried across the posterior surface of the thigh, curving so that this flap is only about one-third as long as the anterior one (Fig. 923). Large flaps are necessary because of the great amount of retraction in the thigh. After the skin and fascia of the anterior flap have retracted, the muscles under this flap are divided obliquely from without inward and the quadriceps tendon is divided at a level which will permit it to be sutured over the end of the femur to the fascia posteriorly. Division of this tendon exposes the subquadriceps bursa, which should be dissected from the posterior surface of the tendon and adjoining muscle, and also from the anterior surface of the lower end of the femur. The large vessels are double clamped, divided, and the proximal ends are doubly ligated. The sciatic nerve or its two branches are gently pulled down after isolation and ligated. Ligation is to control bleeding from the small accompanying artery. The other nerves are gently pulled down, divided, and allowed to retract. The femur should be sawed squarely across above the condyles and the bone carefully treated, as previously described. The broad quadriceps tendon is then sutured across the end of the femur to the fascia posteriorly and the fascia is also sutured to the lateral border of the tendon to prevent too great retraction of the muscles. The skin flaps are approximated with interrupted silk sutures.

When it is necessary to amputate the thigh above the desired level, the chief consideration is the saving of as much bone as possible. For this reason, it is better to do a circular amputation or make very short, equal length flaps (Fig. 924). A thin flap of the quadriceps muscle and its aponeurosis should be sutured across the end of the femur in the same manner as described with the tendon lower down. The fascia should be carefully approximated.

Amputation just below the trochanters may be done by the external oval method, or by a racket incision similar to that used in disarticulation at the hip joint. The incision is begun over the great trochanter in the outer portion of the thigh, is carried down the outer portion of the thigh for about 10 cm., then across

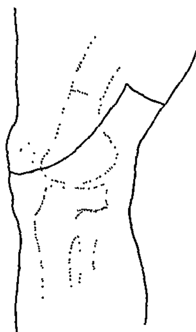


Fig. 923.—Anterior flap method of amputation through lower third of thigh.

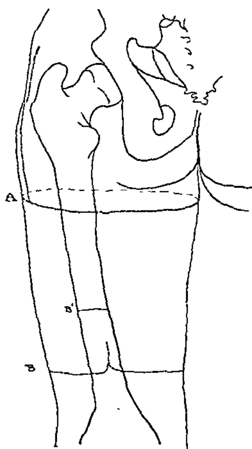



Fig. 924.—*A*, Lines of incision for amputation of the hip joint by the method of Wyeth (the external racket incision). *B*, Lines of incision for amputation of the thigh by modified circular method; B', corresponding level section of femur.

carefully dissected out so that the depression which is left in the tendon will fit the end of the femur. The synovial lining of the subquadriceps bursa is nc moved, so that little raw area is exposed to possible infection. The femur is di just proximal to the adductor tubercle and all sharp corners and angles are rem from the end of the bone. The tourniquet is removed and the flaps are insp for bleeding vessels which are carefully ligated. The flaps are loosely approxin with a few interrupted sutures, if there is no obvious infection in the adjacen sues. In the presence of active infection distal to the site of amputation, espe if anaerobic organisms are found, the wound may be left open or loosely packe

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the head of the femur is dislocated by rotating the thigh. If this proves difficult, which is unusual, the margin of the acetabulum may be chipped away with a chisel to admit air. If the vessels have been ligated, the tourniquet may be removed and the disarticulation completed. After the tourniquet is loosened, all bleeding vessels

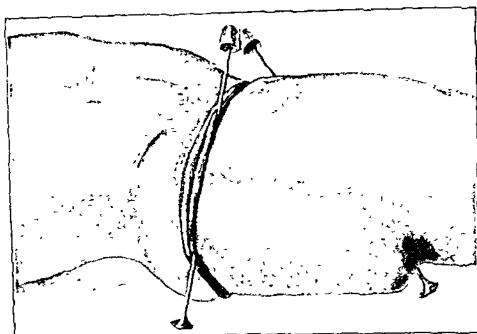


Fig. 925.—The method of Wyeth for hemostasis in amputation at the hip joint.

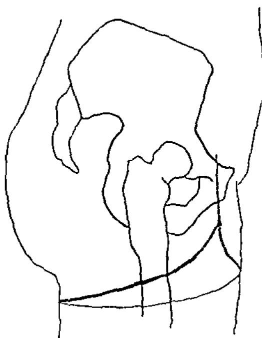


Fig 926—Lines of incision for amputation at the hip joint by the anterior racket incision.

should be clamped and ligated. The muscles and fascia are approximated by mattress sutures of catgut. The skin is sutured from within outward in a continuous line, and an abundant compression dressing is applied. Wyeth's method is rarely used now.

If a tourniquet is not used, the anterior racket incision is more satisfactory. It begins about the center of the inguinal ligament, is carried down over the femoral

the front and inner aspects of the thigh in an oval manner. The posterior incision begins about 10 cm. below the upper end of the vertical incision and passes downward and backward, meeting the anterior incision of the back of the thigh at a point about 15 cm. below the level of the trochanter major. The skin and fascia are dissected up for about 5 cm. along the line of incision and the shaft of the bone is exposed through the vertical incision. The muscles are then divided by a circular incision in a line with the retracted flap and the femur is sawed squarely across just below the trochanter. The muscles and fascia are approximated with mattress sutures of catgut and the skin flap is sutured in a horizontal line from within outward.

## HIP JOINT

The great problem in amputation just below the trochanters or at the hip joint is the control of hemorrhage. Amputation in this region may be done best by an anterior racket incision, which first exposes the femoral vessels so that they may be ligated and divided in the early stage of the operation. When there is much disease about this joint, it is frequently desirable to make a separate incision for ligation of the common femoral vessels, and if the profunda femoris comes off at an unusually high level the incision may be extended above Poupart's ligament and the external iliac vessels ligated. With careful dissection the bleeding points are clamped as they are reached, with but little loss of blood. When there is no lesion at the level of the hip joint which may be adversely affected by a tourniquet, the bleeding may be controlled by the application of a rubber tourniquet according to the method of Wyeth (Fig. 925). In this method, pins or long mattress needles about 0.3 to 0.6 cm. in diameter and about 25 cm. long are inserted through the thigh. One pin is passed through the outer portion just below and to the inner side of the anterior superior iliac spine. It traverses the superficial muscles and fascia on the outer side of the hip and emerges about 7.5 cm. from, and on the same level with, its point of entrance. The second pin is introduced on the inner portion of the thigh about 1.25 cm below the perineum and internal to the saphenous opening, through the adductor muscles, to emerge about 2.5 cm below the tuberosity of the ischium Sterile corks are stuck on the sharp ends of the pins to prevent injury to the hand of the operator. A small gauze pad is placed over the femoral artery, and rubber tubing about 1.25 cm in diameter is wrapped tightly four or five times around the thigh just above the needles and fastened by clamping the ends with heavy forceps A circular incision is made around the thigh about 15 cm. below the anterior part of the tourniquet, and then a vertical incision is begun above the great trochanter just below the tourniquet and is carried down to join the circular incision The circular incision goes through only the skin and fascia, which are dissected up to the level of the lesser trochanter, a distance of about 5 cm Here the muscles are all divided by a circular incision and the vertical incision is deepened to the bone The large vessels are clamped and tied. Through the vertical incision the tissues are separated from the shaft and tuberosity of the femur and retracted. The muscular attachments to the trochanter are divided with scissors while the limb is rotated alternately inward and outward. The capsular ligament is divided at its outer anterior border and the cotyloid ligament is incised to let air in the joint and thus overcome joint suction. The posterior portion of the capsule is next divided and

ischial tuberosity. The ischiocavernosus and transversus perinei are elevated subperiosteally from the rami. The ligaments and fibrocartilage of the symphysis pubis are divided with an osteotome. (Fig. 929.)

The incision along the iliac crest is extended posteriorly to the posterior superior iliac spine From the spine it is carried abruptly outward to the greater trochanter. Thence it arches backward and downward into the gluteal crease, continuing into the perineum to join the perineal incision. The gluteus maximus muscle is exposed along its posterior and inferior borders Its aponeurosis is incised according to the skin incision. A large flap of skin, fat, and the gluteus maximus muscle is elevated This flap is retracted The hip rotator muscles, the gluteus medius muscle, and the sciatic nerve are thus brought into full view (Fig. 930).

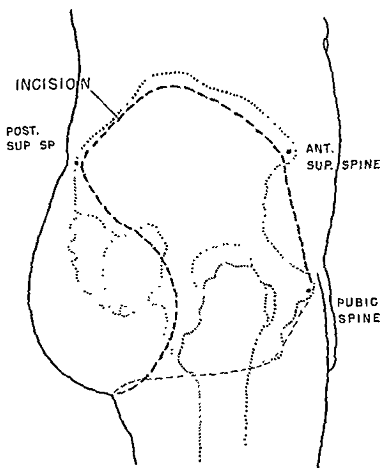



Fig. 927.—Skin incision for hindquarter amputation.

The pyriformis muscle is severed. The sciatic nerve is divided *after ligation*. The ilium is sawed through by passing a wire saw into the pelvis *through the greater* sciatic notch. The saw is brought out over the iliac crest just in front of the sacroiliac joint (Fig. 930). The sacrotuberous and sacrospinous ligaments are severed. Now the innominate bone rotates externally with the extremity so that a wide intrapelvic exposure is given. The obturator vessels and nerves are ligated. The psoas muscle is cut at the sacroiliac joint. By severing the levator ani muscle close to the pubic bone the extremity and innominate bone are completely freed (Fig. 931). The wound is closed by drawing forward the flap fashioned out of the gluteus maximus. It is sutured to the rectus abdominis, the lateral abdominal, the quadratus

artery for about 7.5 cm., then curves medially and across the medial side of the thigh about 10 cm. below the perineum (Fig. 926). From this point it is carried across the posterior and lateral aspect of the thigh a short distance below the great trochanter and then curves upward and medially to join the lower end of the vertical incisions about 7.5 cm. below the inguinal ligament. Through the vertical portion of the incision the femoral artery and vein are exposed, carefully ligated, and divided. Two ligatures at distances of about 0.5 to 1.0 cm. are placed upon the proximal end of the artery, as has been advocated in the ligation of all large vessels The skin and fascia are freely dissected along the entire incision and the muscles on the outer side of the thigh are divided. The external circumflex artery is doubly clamped, divided, and tied. The thigh is elevated, the dissection is carried backward, and the insertion of the gluteus maximus muscle is divided. The thigh is then rotated and the posterior and medial muscle is divided. Bleeding points are carefully clamped and the internal circumflex artery is identified and ligated. The muscles of the medial side of the thigh are divided on a level with the retracted skin. The thigh is adducted and rotated inward and the muscles attached to the greater trochanter are severed. The femur is then adducted and rotated outward, the capsule is cut, and the head of the bone is disarticulated. The remaining structures are severed and the wound is closed as previously described, except that the line of suture runs from before backward, instead of from within outward as with Wyeth's method. By careful technic this procedure can be carried out with little loss of blood and therefore with little shock.

## HINDQUARTER

Hindquarter or transiliac amputation is indicated in those cases of malignant tumors affecting the proximal portion of the thigh, hip, or innominate bone where removal by hip disarticulation is impossible. Occasional traumatic injuries and chronic hip infections may require this type of operation Good general condition of the patient and the absence of metastatic lesions are of importance in making the decision to do this operation.

On the morning of operation the lower bowel is cleansed by enema. The bladder should be emptied in the operating room by catheterization. Sufficient properly typed blood must be available in the operating room. Before starting the operation a large needle is securely placed in a suitable vein for the transfusions.

The patient is placed in the full lateral position. The blood in the extremity to be removed is saved by applying a tight compression bandage to the elevated leg

The technic for the operation according to King and Steelquist falls naturally into three parts: anterior, perineal, and posterior. Beginning at the pubic tubercle the incision extends upward and outward along the inguinal ligament to the anterior superior spine of the ilium (Fig. 927 ) Thence, posteriorly along the iliac crest. After detaching the abdominal muscles and inguinal ligament from the iliac crest, the iliac fossa is opened between the peritoneum and iliacus. The inguinal ligament and the rectus abdominis tendon are severed at the pubis. The cord is retracted medially, the space of Retzius is opened, and the bladder is retracted into the pelvis The external iliac vessels and the femoral nerve are located, ligated, and cut (Fig 928) This wound is packed tightly with gauze.

After abducting widely the extremity, the incision is carried downward and outward from the pubic tubercle along the rami of the pubis and ischium to the

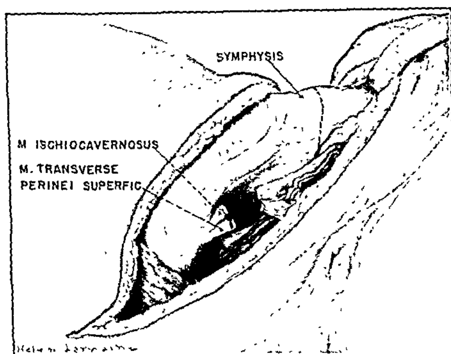



Fig. 929.—The peroneal stage of the hindquarter amputation The dotted line marks the site of the incision through the symphysis pubis.

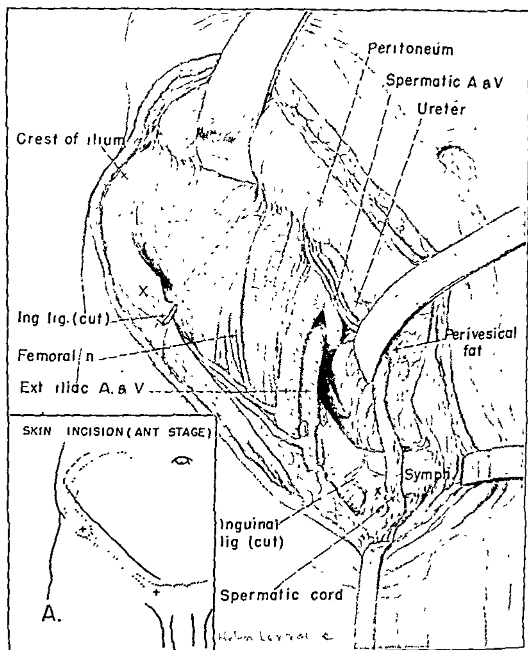



Fig. 928.—Hindquarter amputation. The anterior stage showing the exposure of the great vessels before ligation.

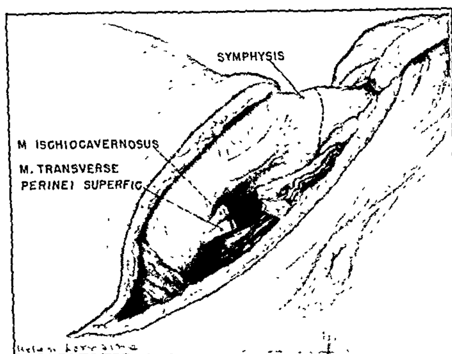



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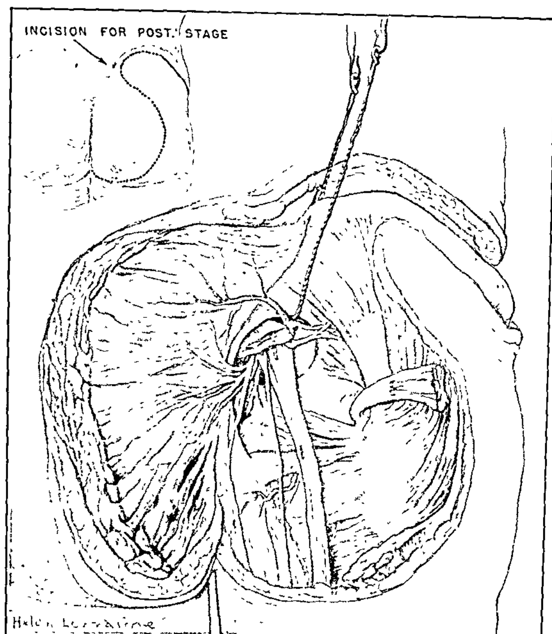



Fig 930.—Posterior stage of the hindquarter amputation. The Gigli saw has been placed for incision of the sacroiliac joint.

Fig. 931.—The hindquarter amputation completed except for the closure of the flap.

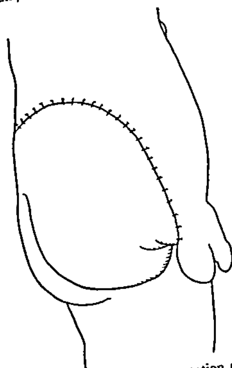


Fig. 932—Hindquarter amputation completed.

lumborum, and the psoas muscles (Fig. 932). Over three or four soft rubber drains, skin sutures are placed. The drains are removed in forty-eight to seventy-two hours.

The patient is kept on a liquid diet for a week to prevent fecal contamination of the wound. Catheterization is continued as necessary. The patient is encouraged to turn and move about in bed as early as possible.

## THE CARE OF STUMPS

The aftercare of amputation stumps is very important, but this phase of the treatment is frequently neglected. In amputations in which for any reason the flaps are retracted and tense, the device described by Lockwood (Fig. 933) is useful in releasing tension on the flaps. Some similar method should be used to prevent retraction in all open amputations.

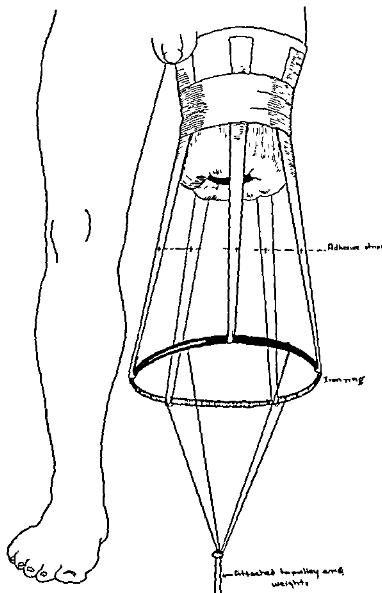


Fig. 933.—Lockwood's method of preventing or overcoming retraction in circular amputations.

Edema often persists in amputation stumps for several weeks after the incision has healed, and no permanent appliance should be used until it has subsided. Disappearance of the edema may be hastened by suitable pressure bandages and by elevation and massage of the stump. The use of a temporary artificial limb, with

a plaster or leather bucket, is desirable as some disability is nearly always present in the joint above the amputation, and this likewise should receive massage, active and passive motion, and baking. A provisional limb should be fitted as soon as the wound is firmly healed and the patient should be urged to begin getting about on it, either with or without crutches. By this exercise the circulation is improved, muscle atrophy and joint contractures are prevented, a permanent artificial limb can be fitted earlier, and, last but not least, the patient's morale is improved.

Flexion contractures of the thigh should be prevented by maintaining a neutral position of the thigh after operation. The extremity should *not* be flexed by elevating the leg on pillows. The proper bed posture should be enforced immediately to prevent contracture.

Satisfactory provisional appliances may be made of plaster. The bucket or socket is made of this material, which is applied in the form of bandages carefully molded to the stump so that it supports the usual bony prominences and in addition exerts even pressure on the entire contour of the stump. Pressure can be modified to comply with the characteristics of the size and shape of the stump. The lower end of an ordinary crutch may be fitted to the plaster socket and makes a useful and inexpensive peg. Artificial legs or setups without sockets can be attached to the plaster socket. As the stump changes, new plaster sockets are made. When shrinkage of the stump has occurred, a permanent appliance should be obtained.

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## CHAPTER 70

# THE KIDNEY AND URETER

Austin I. Dodson

## GENERAL CONSIDERATIONS

The progress in the diagnosis and in the cystoscopic treatment of urologic diseases makes it advisable to consider these phases of the subject as a preface to any discussion of surgery of the genitourinary system.

The kidneys and ureters can be accurately visualized by instrumental or by intravenous pyeloureterography. When cystoscopic examination is not advisable, the contour of the bladder, together with diverticula, tumors, or an enlarged prostate, can be accurately outlined by an x-ray examination following the introduction of a contrast substance. Many urologic conditions formerly requiring operation are now relieved by modern cystoscopic methods, while irrigation and drainage of an infected kidney containing a stone by indwelling ureteral catheters diminish the infection, thereby lessening the hazard of operation, and often making possible a nephrectomy or pyelotomy when, otherwise, nephrectomy would be indicated.

There is no branch of surgery in which a more accurate diagnosis is possible than in urology, nor in which preliminary treatment offers so much in eliminating the hazards of operation Furthermore, cystoscopic treatment is often an essential part of the postoperative care.

## THE KIDNEY

If the kidney is the site of disease, many interesting problems present themselves. It is necessary to know the functional capacity of each kidney and to estimate the recuperative power of the diseased kidney should palliative measures be adopted A severe pyelitis or an impacted stone will often cause temporary suppression of function from one kidney, which function will be resumed if the cause is removed By too hasty action in such cases the useful kidney may be sacrificed.

Nephrectomy is usually indicated in tuberculosis of the kidney regardless of the stage of the disease or the function of the diseased organ, provided the other kidney is free from infection.

Cases are occasionally seen with a tuberculous bacilluria and with a few red cells and leukocytes in the urine, but with normal kidney function and no structural changes in the pyelogram. Such early cases occasionally heal. If the function of the kidney is diminished, if the pyelogram indicates destruction of tissue or changes in the contour of the ureter, or if there are ulcers in the bladder, cure is dependent upon nephrectomy. In cases in which one kidney is far advanced in disease and

causing septic symptoms, and the other kidney mildly infected and having good function, the patient will enjoy improvement in health and longer life if the more diseased organ is removed.

As a general rule, multiple stones in the kidney or recurrent stones require nephrectomy. A more conservative course may be taken if the kidney has good function and there is very little infection or if the opposite kidney is diseased. Pyonephrosis is a very obstinate condition to treat, and, whether it is accompanied by stone or not, if the disease is unilateral, nephrectomy should usually be done.

Hydronephrosis, if seen before the function of the kidney has been destroyed, can frequently be relieved by conservative means. If due to twists or kinks of the ureter, adhesions can be broken up, the kidney anchored at a higher level, and better drainage obtained. Obstructing stones may be removed, aberrant vessels divided, and strictures dilated by a bougie passed through the cystoscope.

In selected cases plastic operations upon the pelvis of the kidney or upon the ureter designed to improve drainage may prevent further destruction of the kidney and improve its function. The principle of renal counterbalance, as advocated by Hinman, should be borne in mind; that is, an injured kidney working with a healthy one has not the same stimulus to repair as an injured kidney working alone or when a similar disease exists on the opposite side. Plastic operations are, therefore, more successful when performed upon solitary kidneys or for bilateral hydronephrosis. When there is a normal kidney on the opposite side, it is well to test the diseased kidney's potential function by inserting an indwelling ureteral catheter a few days before operation. If the kidney's function is not half that of its healthy fellow and if this function does not improve with adequate drainage, nephrectomy may be advisable. The appearance of the renal parenchyma at operation is important.

Polycystic kidney is a bilateral condition and nephrectomy is advisable only when secondary disease, such as stone or infection, endangers the life of the patient. When there is persistent pain or hypertension, excision or incision and drainage of all approachable cysts will usually alleviate the symptoms, improve renal function, and prolong the life of the patient. Simple cysts of the kidney are associated with interstitial nephritis and are not often bilateral. If the kidney is functioning, it should not be removed.

Cortical abscesses usually demand nephrectomy. There is too much danger of infection and secondary hemorrhage if an attempt is made to resect the diseased portion of the kidney. If nephrectomy cannot be done because of poor function in the opposite kidney, the abscess should be drained and antibiotics administered.

Operative treatment should be a last resort in idiopathic or essential hematuria. Stripping the capsule and bisection of the kidney have been tried with rather doubtful results. Should the bleeding be sufficient to endanger the health of the patient, nephrectomy is the operation of choice.

There is usually improvement in the function of the sound kidney following the removal of a markedly diseased one. This is not altogether due to work hypertrophy, for often these diseased kidneys have been functionless for months. By extirpating the diseased kidney, an extra burden of toxic material is removed from the sound kidney as well as the danger of becoming secondarily infected.

Regardless of the pathologic condition existing, surgical judgment must be largely influenced by the functional capacity of the supposedly normal kidney, obtained by the differential function test. Phenolsulfonphthalein is usually employed.

Six milligrams dissolved in 1 c.c. of water are given intravenously, and specimens of urine are collected separately from catheters in each ureter. The specimens are collected in bottles containing a few drops of an alkaline solution, so that when the dye appears in the urine the specimen turns red. In a normal kidney the dye should appear in the urine in from five to seven minutes, and in the first twenty minutes about 1 per cent a minute should be eliminated. Frequently when one kidney has been functionless for a long time, its fellow will eliminate as much as 30 per cent of the dye in twenty minutes. When one or both kidneys cannot be catheterized, or when it does not seem advisable to do so, indigo carmin is useful as a rough indicator of the kidney's function. It is given intravenously, and its appearance from the ureters is observed through the cystoscope. It appears in about the same time as phenolsulfonphthalein, and a kidney is considered practically functionless if there is no appearance of the dye in twenty minutes.

A severe pyelitis or stone in the kidney pelvis or ureter will often cause a marked diminution of function without noticeable destruction of the kidney parenchyma. The normal function will be resumed in these cases following the removal of the irritating factor. There are other cases in which the symptoms have existed for a number of years and in which a pyelogram shows the kidney pelvis to be markedly dilated, with the calyces practically effaced. In such cases there is very little hope for improvement in function, and nephrectomy is the quickest and the best means of relief for the patient.

In recent years the ureter has occupied an increasingly prominent place in the surgery of the urogenital tract. The lesions of this tube, usually obstructive in character, are chiefly important because of their interference with the drainage of the kidneys. Strictures and stones, the most common lesions, are usually treated successfully by cystoscopic methods. Impacted calculi, very dense strictures and those at the ureteropelvic junction, kinks accompanied by adhesions, tumors of the ureter, and injured ureters demand operation for relief. In such instances, it is necessary to have a thorough knowledge of the function of each kidney. Occasionally it will be found that a nephrectomy is the operation of choice. Transplantation of the ureter into the large bowel, into another area of the bladder, or onto the skin is being practiced with increasing frequency because of the more radical methods of treating malignant disease of the bladder.

## OPERATIONS ON THE KIDNEYS

Incisions for exposure of the kidney are so important in the technic of kidney operations that they should be considered at some length. Three incisions for exposing the kidney cover all indications for operations on this organ. Two are lumbar incisions. The simplest of these, the vertical incision of Simon, may be used in operations for fixing the kidney or for a simple exploration in a thin patient. This incision is made along the outer edge of the erector spinae muscle and goes vertically from the last rib downward to near the crest of the ilium. The fibers of the latissimus dorsi are separated and retracted but not cut. The erector spinae muscle is retracted inward and the sheath of the quadratus lumborum is opened along the length of the wound. The incision approaches the lower rib, but if carried too close to the rib the pleura may be injured. This accident, however, can usually be avoided by pushing the tissues out of the way and by separating the



Fig. 934.—Lumbar incision for exposure of the kidney. The incision may be extended as far forward as necessary (From Dodson. Urological Surgery, The C. V. Mosby Co )

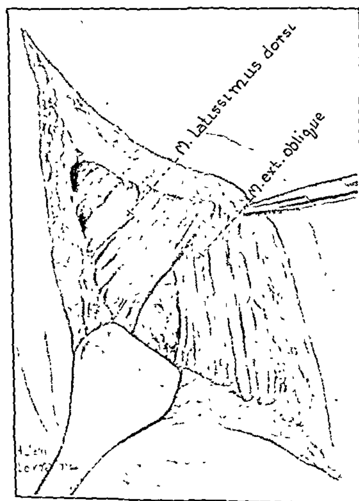



Fig 935.—The superficial tissues have been divided, exposing the muscles and Petit's triangle.

tissues chiefly by blunt dissection up to the lower border of the rib. The transversalis fascia is recognized and opened at the upper part of the wound, and the fatty capsule of the kidney bulges into the wound. The iliohypogastric and ilio-inguinal nerves lie between the quadratus lumborum and the kidney and are protected by careful retraction outward and downward They should also be recognized when the wound is closed so they will not be included in the bite of the suture. This incision is very satisfactory for exposure or fixation of a loose movable kidney in a thin person or for removal of a stone in such an individual As a rule, however, when operation for stone is indicated, or when the kidney is to be removed, a more extensive lumbar incision should be made.

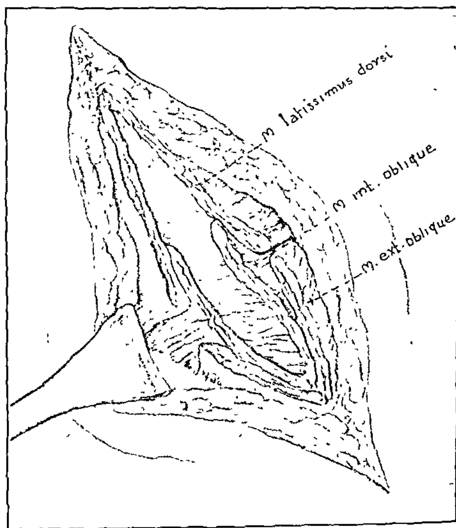



Fig 936.—The muscles have been divided and the transversalis fascia bulges into the wound.

The lumbar incision is made by beginning just above the twelfth rib and at the external margin of the quadratus lumborum muscle The excision is carried downward and slightly forward to a point midway between the twelfth rib and the crest of the ilium where it curves forward parallel to the crest of the ilium It is carried forward as the indications may demand (Fig. 934) When the skin and superficial fascia are divided, the latissimus dorsi and the external oblique muscles are exposed, and between the two is seen the upper angle of Petit's triangle (Fig. 935). The latissimus dorsi muscle is then divided as far upward as necessary to give adequate exposure at the upper angle of the wound At least a portion of

the serratus posterior inferior muscle, which lies beneath the latissimus dorsi, is divided at the same time. This exposes the superior lumbar triangle and the lumbar fascia. The posterior fibers of the external and internal oblique muscles, which cross the lower portion of the wound, are then divided. The extent of the incision in these muscles depends upon the stature of the patient and the size of the kidney to be exposed. Occasionally in thin, tall patients with poor muscular development these muscles may be left intact and retracted forward sufficiently to give ample room below, but in most cases it is necessary to divide them at least two or three inches. After these muscles have been divided, all bleeding should be controlled entirely before opening the lumbar fascia (Fig. 936). The transversalis (lumbar) fascia is now freely incised, the ilioinguinal and iliohypogastric nerves are identified and retracted out of the way (Fig. 937).

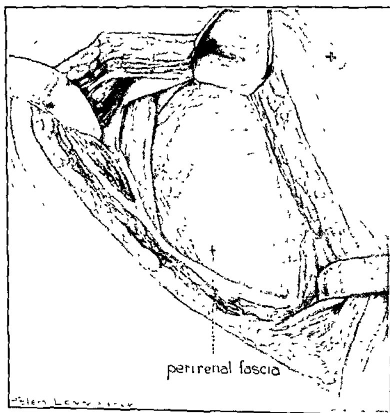



Fig 937.—The kidney covered by fat and fascia adequately exposed.

The posterior part of the twelfth rib is cleared backward and upward almost to the articulation of the rib with the twelfth dorsal vertebra and the pleura is pushed upward. When the attachments of the quadratus lumborum and the lateral arcuate ligament which binds down the twelfth rib are divided, the twelfth rib can be retracted upward and outward, which gives an excellent exposure. The edge of the erector spinae muscle is retracted toward the spine. This incision can be used for all operations upon the kidney in which the kidney is not more than two or three times its normal size. It permits a more accurate study of the kidney and ureteropelvic area than is possible with the vertical incision even in thin patients.

When the kidney is considerably larger than normal, and especially in large tumors of the kidney, an anterior abdominal incision should be made. This, called

the incision of Langenbeck, begins just below the rib about 7 cm. from the midline and is carried downward along the outer border of the rectus muscle in the linea semilunaris.

The peritoneum is opened and the colon and its mesentery are retracted toward the midline along with the rest of the abdominal contents. The kidney is then exposed by a vertical incision in the parietal peritoneum external to the mesocolon

*Nephropexy*

The purpose of nephropexy is to suspend the kidney and to create adhesions that will hold it in place, thereby improving drainage. The operation is indicated when ptosis of the kidney interferes with drainage or when persistent pain or gastrointestinal disturbances result from the excessive mobility. The kidney should also be suspended following plastic operations on the kidney pelvis, or when during any conservative operation the kidney has been completely mobilized.

Numerous methods of fixing the kidney in place have been devised, any one of which is apt to be successful if care is taken to suture the kidney in its normal anatomical position.

Regardless of the method to be used, the preparation of the kidney and its bed is the same. Adequate exposure is necessary so that the kidney and ureter above the pelvic rim and renal fossa can be easily seen. An ample curved lumbar incision (Fig. 934) is usually more satisfactory, though in very thin patients with adequate space between the costal margin and iliac crest Simon's incision is sufficient and causes less discomfort during convalescence. After the incision is made and all bleeding vessels are ligated, the operation is continued by first separating the posterior portion of the perirenal fascia from the lumbar muscles as far posteriorly as practical. A longitudinal incision is then made in the fascia opposite the medial border of the kidney and extended both upward and downward. A clean incision in the fascia permits it to be reflected forward and preserved intact for use in protecting and supporting the kidney when it has been placed in its bed. The fascia after having been divided is carefully dissected from the kidney and, together with the perirenal fat, is reflected medially, carrying before it the parietal peritoneum. These structures are retracted anteriorly, giving adequate exposure to the kidney and renal fossa When adhesions from the perirenal fascia to the kidney are not readily separated by blunt dissection, they should be divided with scissors to prevent tearing the renal fascia. The kidney thus exposed is held by an assistant while the surgeon separates all adhesions from the lower pole of the kidney, beginning at the convex border and continuing around the lower pole until the ureteropelvic area is reached. Small blood vessels entering the lower pole are ligated and divided. If the vessel is large enough to supply an extensive area of the kidney, it should be preserved When the ureteropelvic area is reached, the ureter is identified and carefully liberated as far downward as can be done with safety All adhesions are divided and any kinks or other obstructive lesions corrected Adhesions are then separated from the renal pelvis and the ureteropelvic area is examined If there is stenosis of the pelvic orifice or high implantation of the ureter, an appropriate plastic operation should be done. After the lower pole, pelvis, and ureter have been freed of adhesions, the assistant retracts the kidney downward, slightly elevating the upper pole while all fat and adhesions are separated from this area and from the vascular pedicle. The kidney is now ready to be

fixed in place. The renal fossa is prepared by removing all fat and fascia from the lumbar muscles well above the costal margin. Occasionally, the liver encroaches upon this area and light adhesions must be broken to permit the kidney to be placed in a sufficiently elevated position.

The operation devised by Kelly is frequently employed and gives excellent results. After the kidney has been prepared as described above, three triangular sutures, as devised by Broëdel, are placed in the true capsule on the posterior surface near the external border. The upper suture is placed at the junction of the

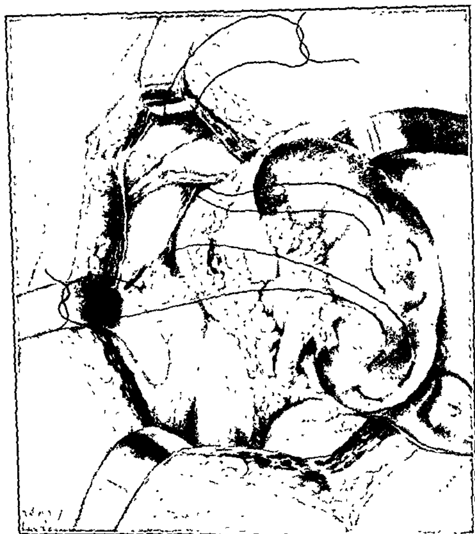


Fig. 938.—Modified Kelly nephropexy. After freeing the kidney and upper ureter, two sutures are taken in the capsule of the convex border of the kidney. The upper suture is carried above the twelfth rib as far posteriorly as possible, and the lower suture is inserted through a portion of the quadratus lumborum at an appropriate distance below.

upper and middle thirds of the kidney, the lower suture near the lower pole, and the middle suture midway between the two. Kelly used white silk which penetrated the kidney about a centimeter in depth. Because of an occasional sinus resulting from silk, No. 1 chromic catgut is more satisfactory, and if the sutures are properly placed and tied while the kidney is held in position it is not necessary to include renal tissue in the suture.

Only two suspending sutures are necessary in this operation. The upper suture is placed at the junction of the middle and lower thirds of the kidney and carried

above the twelfth rib as far posteriorly as possible. The suture taken at the lower pole is sutured to the quadratus lumborum muscle an appropriate distance below the first (Fig. 938). After the kidney has been elevated in position and the sutures have been pulled taut, the kidney elevator is lowered and the kidney and ureter are examined before the sutures are tied. The upper pole of the kidney should point a little medially and the lower pole outward to insure good drainage of the lower calices The ureter should be straight but not taut, and there should be no tension on the vessels of the renal pedicle. If all is in good order, the suspending sutures are tied. The perirenal fascia and fat are then brought across the anterior surface of the kidney and sutured to the lumbar muscles immediately below the kidney.

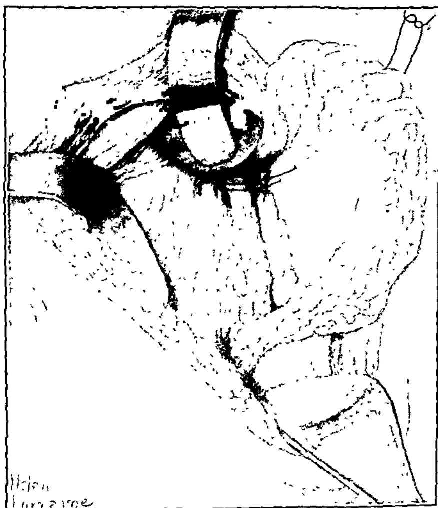


Fig. 939.—Deming nephropexy The kidney has been prepared and is being held up in its new bed by a retractor The first suture has been taken near the ureter to suture the perirenal fascia and fat to the quadratus lumborum muscle.

The operation devised by Deming depends entirely upon the perirenal fascia and fat to hold the kidney in place. No sutures are placed in the kidney or its capsule. The perirenal fascia and fat are accurately sutured to the lumbar muscles below the kidney.

The following paragraph is abstracted from Deming's description of the operation:

The perirenal fat is all stripped off the kidney which, with its vessels and ureter, is then delivered into the wound It is important that all adhesions be re-

moved from the upper as well as the lower pole. The ureter, which is either tortuous or badly kinked, should be made free. Special attention should be noted concerning the kidney fossa—whether shallow, absent or deep. The liver sometimes is adherent to the posterior abdominal wall so that it is impossible to place the kidney in its bed without freeing the right lobe. The hand should be inserted under the right lobe of the liver to the diaphragm. When this is done, the kidney can be replaced sufficiently high to remove all kinks and most of the tortuosities of the ureter. The kidney can be made to occupy practically an intrathoracic position with the lower pole lying opposite the last rib. The upper pole should be carried medially and the lower pole outward to give independent drainage to the lower



Fig. 940.—Deming nephropexy. Four mattress sutures have been placed, suturing the fat and fascia to the quadratus lumborum muscle and holding the kidney securely in its elevated position.

calyx. With the kidney held in position, a series of interrupted mattress sutures of 0 chromic catgut is placed through the perirenal fascia and peritoneum to the quadratus muscle. Perirenal fascia is always excessive so that it is easily approximated Precautions must be taken not to include the bowel medially. The first stitch should be placed about one centimeter from the ureter and as high as possible on the quadratus muscle posteriorly. (Fig. 939.) Care should always be taken not to include any nerves in these sutures of chromic catgut. A series of five to eight sutures is necessary to close this aperture. These form a basket sling for the kidney so that it is impossible for the organ to descend. (Fig. 940.) This row of sutures is now reinforced by bringing up all the extraperitoneal fat and suturing it with two or three mattress sutures to the quadratus muscle below the other line

of sutures. This fat acts as a support and fills the space previously occupied by the kidney. The wound is then closed in layers with 0 chromic catgut and the skin with interrupted silk sutures.

Deming's operation is certainly the most physiologic of any so far devised. Neither the kidney nor its capsule is disturbed, and it is held in place at least in part by normal support. Adhesions certainly occur between the renal capsule and the kidney bed to help hold the kidney in place. Removal of a portion of the capsule is not necessary for this purpose.

**Postoperative Care.**—The postoperative treatment is rather important following nephropexy. The patient should lie on the side operated upon for a few hours immediately following the operation, and should be kept either on that side or on the back one week before being permitted to lie on the other side. The foot of the bed should be elevated about 8 to 10 cm during this time. A small pillow may be used under the head. Otherwise the immediate postoperative treatment is the same as that for other patients who have had an operation upon the kidney. At the end of a week the foot of the bed may be lowered and the patient permitted to lie on either side, but he should be kept flat in bed for another week. At the end of the second week a snug abdominal binder is applied and the patient is permitted to sit up, first in bed, and in twenty-four hours in a chair. The patient may return home as soon as he or she is strong enough to walk. Strenuous exercise, lifting heavy objects, and long automobile rides should be prohibited for at least two months. During this time a snug abdominal binder or support should be worn.

## Nephrectomy

In nephrectomy for a condition in which the kidney is not much above the normal size, the lumbar incision is very satisfactory. After exposure of the kidney, the fatty capsule is split and bluntly dissected away. It is important to recognize the true capsule of the kidney after splitting the fatty capsule. The kidney is seized with the hand and, by gentle traction, delivered into the wound. By strong retraction of the abdominal wound the pedicle is recognized. Fat is carefully separated from the renal artery and vein. If the pedicle is sufficiently long, a ligature of catgut is carried around the renal artery and vein and tied The ligature should be placed as far from the kidney as possible, and then a second ligature toward the kidney is placed 1 cm. from the first ligature. The ureter is separated from the rest of the pedicle and a clamp is applied to the renal artery and vein close to the kidney to prevent soiling with reflux blood The renal vessels are divided close to the clamp, leaving the kidney attached solely to the ureter. As much of the ureter as is thought necessary is stripped up and the ureter is doubly ligated with catgut at the lower angle of the wound and divided between ligatures. Not infrequently there are anomalous polar arteries which must be identified and tied Often when the pedicle is difficult to expose it cannot be satisfactorily ligated before the kidney has been removed Here the pedicle is treated by seizing it with two forceps after the ureter has been divided between two ligatures. The stump of the ureter is disinfected, and in tuberculosis 5 to 18 minims of carbolic acid are injected into the lumen of the distal part of the ureter with a hypodermic syringe. It is better to inject the carbolic acid before the ureter is clamped or tied The portion of the ureter attached to the kidney is dissected up well to the pelvis of the kidney so that

it will not be included in the clamp on the pedicle. As much fat as possible is removed from the pedicle and then the pedicle is clamped with two forceps about 1.5 cm. apart and another forceps near the kidney. The kidney is removed after severing the pedicle between the distal two forceps (Fig. 941). A catgut ligature

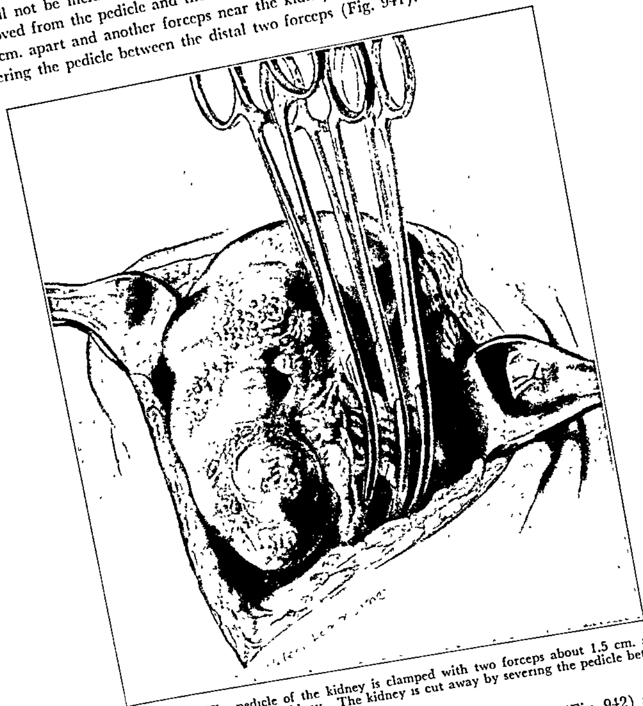


Fig 941 —The pedicle of the kidney is clamped with two forceps about 1.5 cm. apart and another forceps near the kidney The kidney is cut away by severing the pedicle between the distal two forceps

is thrown around the pedicle beneath the deeper pair of forceps (Fig. 942) and is tied as this clamp is slowly unlocked so that it sinks into the groove made by the forceps (Fig 943). A second ligature, which is placed with a needle that transfixes the pedicle, is tied while the distal forceps is slowly removed. Both ligatures are of catgut The first knot is single and may be held with mosquito forceps to prevent slipping while running down the second knot. If the nephrectomy is for sepsis or tuberculosis, the infiltration of the tissues may make it impossible or unwise to ligate the renal vessels separately, and the support of the surrounding tissue which

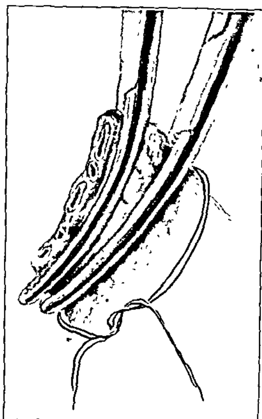


Fig 942.—A catgut ligature is thrown around the pedicle beneath the deeper pair of forceps

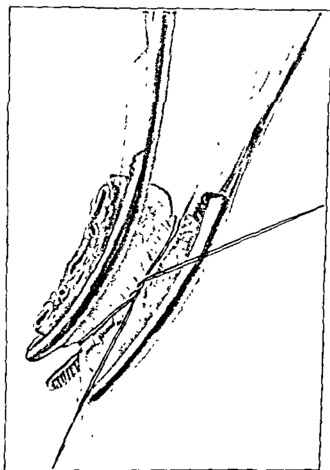


Fig 943.—The ligature is tied as the clamp is slowly unlocked.

has been crushed by forceps in the manner indicated adds to the safety of the ligatures. If on account of the obesity of the patient or the shortness of the stump it is impossible to apply two forceps, one forceps may be used and the ligature passed through a margin of the pedicle and tied in a single knot in order to fix it in position. The ends of the ligature are then carried around the pedicle and securely tied in the groove left by the forceps. Occasionally, instead of a ligature, the forceps may be left on and removed after forty-eight hours.

The treatment of the pedicle in a nephrectomy is an exceedingly important part of this operation, first, because of the control of hemorrhage, and, second, because if the nephrectomy is done for a malignant tumor of the kidney, fragments of this tumor may project into the renal vein and if the pedicle is not carefully dissected and secured close to the vena cava at as early a stage in the operation as it can be exposed, manipulations may dislodge some fragments of the growth and force them into the renal vein. It is probable that this accounts for the early hematogenous metastases that occur after nephrectomy for hypernephroma. If the vessels are injured and the bleeding is profuse, pressure with a large piece of dry gauze should be made immediately over the bleeding point. If this controls the bleeding, the edges of the gauze are gradually removed until the bleeding points are exposed and clamped. If the hemorrhage is arterial, the injured vessel should be seized with the fingers. Pulsations of the artery and of the blood stream will lead the fingers to the injured artery. A clamp can then be applied safely. It is a great mistake to attempt to clamp blindly in this region and forceps should not be applied until the bleeding point has been accurately located. Injuries to the vena cava and to the duodenum from indiscriminate and blind clamping may occur and may be fatal.

Before closure of the wound the pedicle is examined and the whole field of the operation is reviewed to see if the peritoneal cavity has been opened or any injury has been done to the duodenum or colon. It is safer to apply drainage either with a tube or a cigarette drain at the upper angle of the wound. The wound is closed in layers with chromic catgut by a continuous lockstitch, or with interrupted sutures, care being taken not to include the ilioinguinal or the iliohypogastric nerves in the sutures. If there is no infection, the drainage can be removed in three days.

The method of procedure during different stages of lumbar nephrectomy depends largely upon the indications for the operation. If done for a malignant growth the chief point is to expose and tie or clamp the renal blood vessels as soon as possible and as far from the kidney as can be safely done. This will prevent metastasis and the ureter may be attended to later, unless its location renders it difficult to secure the blood vessels of the pedicle before severing the ureter.

In some old tubercular kidneys, or in old infected kidneys with stone, delivery of the kidney into the wound is exceedingly difficult. Here subcapsular nephrectomy is indicated. If there has been no previous operation and if no sinus or fistula exists, the lumbar incision is made down to the capsule of the kidney and the capsule is split along the outer border of the kidney and stripped down to the pelvis. Here, according to the method of Federoff, the capsule is divided near the pelvis of the kidney and pushed back, leaving the capsule attached to the fat and the tissues in its neighborhood. The ureter is doubly ligated, and the vessels of the pedicle are exposed. In such cases it is occasionally difficult to secure the pedicle by ligature, partly because of the infiltration of inflammatory products which necessitates the subcapsular method of removing the kidney. Here the pedicle may be

clamped with a stout pedicle forceps. The clamp is left on two or three days and is then unlocked but left in position twelve hours longer, when, if there is no bleeding, it is gently removed.

When the kidney is much enlarged, particularly from malignant growths, the nephrectomy may be done through an anterior abdominal incision. Ample exposure is given by the incision that has been described along the linea semilunaris The peritoneum at the root of the outer mesentery of the colon is incised and the colon with its mesentery is mobilized by gauze dissection and pushed toward the midline. The intestines are kept out of the way and protected by packs of warm moist gauze The pedicle of the kidney is approached if it is possible to do so before any effort is made to mobilize the kidney. The renal vessels are exposed by careful dissection and tied with two catgut ligatures 1 cm apart, the inner ligature being close to the vena cava The vessels are next clamped near the kidney and the pedicle is divided. If this procedure is impossible on account of fat or infiltration of tissue, the two-forceps method, as described in lumbar nephrectomy, is used. The kidney is then mobilized, a sharp lookout being kept for anomalous arteries and veins With a large tumor, the adhesions may be very vascular and thin-walled veins often develop along the adhesions. The ureter is doubly ligated and divided as the last step of the operation, though it may be well to place a double ligature around the ureter immediately after securing the pedicle in order to prevent forcing infectious or malignant material into the bladder. The ureter is divided after the kidney and its tumor have been delivered.

The wound is carefully reviewed to see that no accidental injury has occurred and all bleeding points are secured with catgut ligatures Drainage is established by inserting a pedicle forceps into the cavity left after removing the kidney and pushing the forceps through to the back just external to the margin of the quadratus lumborum until the skin is reached. The skin is then incised over the tip of the forceps after separating the blades, and the forceps are thrust through this skin incision and grasp a soft rubber tube about 1 cm in diameter which is drawn into the wound The tube is fixed to the skin by a suture.

The tube should project only about 2.5 cm. into the cavity left by removing the kidney. The posterior parietal peritoneum is sutured to the outer divided layer of the mesentery of the colon by a continuous suture of catgut. The abdominal incision should be closed with interrupted sutures of coarse silk.

In congenital cystic kidneys the disease is usually bilateral and the chief damage is probably done by pressure of a large number of cysts upon the secreting substance of the kidney. Lund has operated successfully in such cases by exposing the kidney and puncturing the cysts through the posterior surface of the kidney. As the cysts are punctured, the kidney diminishes in size and can be delivered into the wound, when other cysts are palpated and emptied with a large aspirating needle or a small trocar and cannula. The kidney is returned to its bed without drainage. Because congenital cystic disease of the kidney is usually bilateral, a nephrectomy should never be done unless it has been thoroughly established that the condition demands it and that the other kidney is functioning satisfactorily.

In nephrectomy following a previous nephrotomy there are naturally many adhesions. After making the usual incision and surrounding the fistula the capsule is best reached by splitting the fistula down to the cortex of the kidney and then stripping the capsule and proceeding as has been described with a subcapsular nephrectomy.

### Partial Nephrectomy

Partial resection of the kidney, while rarely indicated, may be found advantageous in the treatment of a solitary renal cyst, in removal of the diseased half of a double kidney, and occasionally in nephrolithiasis when the stone is situated at one pole of the kidney surrounded by markedly diseased tissue, the remainder of the kidney being healthy.

Whenever it is possible, the blood vessels supplying the portion to be excised should first be ligated and divided. The remaining vessels of the pedicle may be controlled by an elastic ligature or by the pressure of an assistant's fingers. A V-shaped incision is made between the healthy kidney and the diseased portion. It is important to remove any mucous membrane in the depths of the wound and to avoid entering a calyx in the healthy portion. Deep interrupted sutures of chromic catgut, buttressed with bits of fat or muscle to prevent cutting through the tissue, will close the wound and control the bleeding (Figs. 944 and 945). The margins of the wound may be approximated by a continuous suture of fine catgut.

### Nephrostomy

Nephrostomy is done as an emergency in anuria cases, as a preliminary operation in debilitated patients with large pyonephrotic kidneys when a primary nephrectomy is dangerous, for deviation of the urine following plastic operations on the kidney pelvis, for removal of stone from the kidney, and for permanent drainage when the ureter or bladder is no longer capable of function and nephrectomy cannot be done.

In a large pyonephrotic kidney the best method is to make an incision through the cortex of the kidney, inserting the finger to explore the cavity, to break up isolated pockets, and to remove stones if present and accessible. A large tube is placed in the center of the sac for drainage. Adequate drainage is also placed down to the surface of the kidney and the wound is loosely closed around the drainage tubes with interrupted sutures of silkworm-gut. When the patient has sufficiently improved, a nephrectomy may be done more safely.

For either temporary or permanent drainage of a functioning kidney, the method advocated by Hugh Cabot is satisfactory. After opening the pelvis of the kidney a bent uterine probe is passed through the pelvis and out through the kidney parenchyma. To the end of the probe is attached a thread of heavy silk which is drawn out through the pelvis. A large-winged catheter is pulled into the proper position. If the kidney can be easily delivered into the wound, a thin, curved forceps can be inserted through the pelvis and passed through the cortex to grasp the tip of the drainage tube and pull it into the kidney pelvis.

### Nephrotomy and Pyelotomy

Operations for stone in the kidney are done either by splitting the kidney and extracting the stone through the renal cortex or by pyelotomy. Splitting the kidney, or nephrotomy, involves considerable hemorrhage and destruction of some of its parenchyma. This operation should be reserved only for those stones deep in the substance of the kidney or for very large stones that cannot be extracted through the pelvis without too great damage. The average stone can be removed from the pelvis of the kidney if satisfactory exposure is obtained.

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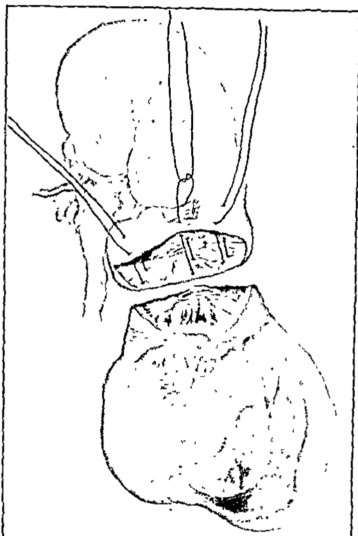


Fig. 944.—Excision of a portion of the kidney. A wedge-shaped section is made so that the wound in the kidney may be more easily closed The wound in the kidney is closed by interrupted mattress sutures of catgut buttressed by bits of muscle or fat

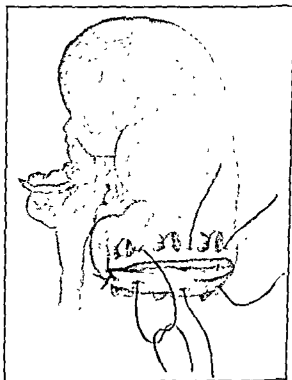


Fig 945.—Closure of the wound The deep sutures have been tied and the margins of the wound are approximated by superficial interrupted sutures.

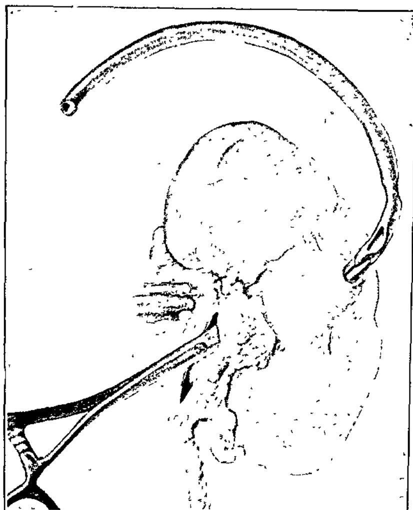
The kidney is exposed by the lumbar incision and is delivered into the wound. The kidney and its pelvis and ureter should be palpated to determine the lesion present. It is then surrounded with moist gauze. Some operators temporarily clamp the pedicle with soft forceps or surround it with a rubber band to prevent hemorrhage during the incision into the kidney. It has been shown, however, that a kidney withstands suspension of its circulation very poorly and the pressure on the pedicle should be frequently interrupted. If the hemorrhage is profuse, an assistant can usually control it for a short time by pressing with his fingers on the hilum of the kidney, using the fingers of one hand in front and of the other behind. This pressure can be relaxed if necessary to restore the circulation or altered to suit the circumstances. If the Brödel line is followed, the hemorrhage is greatly lessened. Brödel has shown that the arteries in the cortex of the kidney are distributed into an anterior and posterior group and that the anterior group is wider than the posterior. The vessels of these two groups to the renal cortex are smallest in size and least in number on a line slightly posterior to the external convex border of the kidney, because the anterior group of vessels supplies a little more than half of the organ. If it is impossible to deliver the kidney into the wound, as sometimes occurs in fat people or where the pedicle is short, too much traction must not be made on the pedicle, but the finger is passed under the kidney to bring its convex border into the wound. An incision is then made slightly posterior to the apex of the convex border and just long enough for the finger to be passed into the pelvis. The stone is located and removed with forceps. The wound in the kidney is closed with interrupted sutures of stout plain catgut, preferably bringing a small tube out through the middle of the wound, but suturing the kidney substance around it as snugly as possible. A mattress suture in the kidney controls the hemorrhage better than an ordinary single stitch, but it has been demonstrated experimentally by Moore and Corbett that the mattress suture produces more injury to the kidney substance than a simple interrupted stitch. If the suture is tied just snugly enough to approximate the incision and the first tie of the knot is held with mosquito forceps while the second tie is being run down, hemorrhage will be controlled, the kidney wound coapted, and a minimum of damage will be done to the kidney substance. If too much tension is put on these sutures, they cut loose and cause additional hemorrhage.

In most cases of stone where the stone is not very large the operation is best done through the pelvis of the kidney. It is necessary to deliver the kidney into the wound and to expose the posterior surface of the pelvis by turning the kidney forward. The fat over the pelvis is incised and dissected back on each side. *It should not be cut away, for it is very useful in covering the line of sutures and it prevents leakage.* Before opening the pelvis the tissues around the kidney are thoroughly protected with gauze in order to prevent soiling of the wound with the escaping urine. After exposure of the pelvis it is incised in the general axis of the ureter. The incision should not be carried too close to the kidney substance because large vessels may be injured and it is difficult to suture this region satisfactorily. A suture of fine chromic catgut is placed in each lip of the wound in the pelvis and the ends are left long to act as tractor sutures. The incision is extended until it is large enough to permit exploration of the pelvis and extraction of the stone. The stone is caught with forceps made for that purpose and should be handled gently

·event crushing it. When the stone is too large to be brought through the ·tomy opening, it may be broken purposely if one is careful to remove all frag-s.

An x-ray equipment at the table for the purpose of taking pictures of the ·ed kidney is helpful in removing fragments or multiple stones.

If fragments are left behind they may form a nucleus for another stone, so it is ·rtant to remove the calculus intact. After extracting the stone the pelvis is ·red with the little finger if the opening is too small to admit the index finger, ·he exploration should be as gentle as possible because the finger can easily ·re veins about the calyces that will cause considerable hemorrhage.



·46.—The pelvis of the kidney has been opened and a forceps is thrust through to the cortex, where it grasps a soft rubber catheter

The next step of the operation depends on whether the pelvis of the kidney is drained. The great objection to pyelotomy is that if a drainage tube is placed the pelvis of the kidney the fistula that results is sometimes very slow in closing ·y operators practice suturing the pelvis without drainage when there is no ·nstrable infection. As the stone is often the result of infection and is fre-·tly accompanied by infection even though it is mild, it seems that drainage ·rule would be beneficial. Drainage of the pelvis of the kidney is best provided ·serting a small blunt pedicle forceps through the wound in the pelvis and ·ting it up through the substance of the kidney toward the middle point of

Brödel's line, where it is shoved through the cortex. A new soft rubber catheter with one or two additional perforations cut near the end is caught and the tip of the catheter is drawn through into the pelvis of the kidney (Fig. 946). When the kidney cannot be delivered it is often difficult to insert a forceps. A uterine probe bent at right angle may be inserted through the pelvis and thrust through the kidney. A suture is passed through the tip of the catheter and tied around the probe. The probe is then withdrawn, pulling the tip of the catheter into the kidney pelvis. The tip should rest well within the pelvis but not far enough down to occlude the ureter. It is fastened in position by a mattress suture of fine catgut which passes through the capsule of the kidney and then through the wall of the catheter (Fig. 947). The incision into the pelvis is closed by a continuous suture of fine chromic catgut. The fat and fascia which were dissected from the pelvis

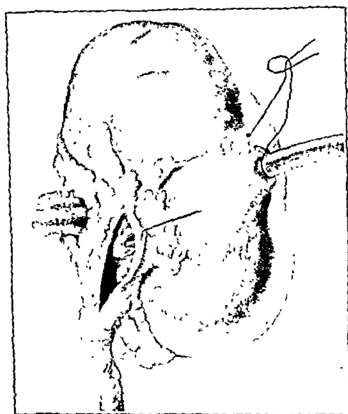


Fig. 947.—The catheter is drawn through so that its tip barely rests in the pelvis of the kidney. The catheter is fastened to the capsule of the kidney with a single stitch.

are brought together over the suture line and fastened with a few interrupted catgut sutures. The packing is removed and a small cigarette drain is carried down to near the pelvis of the kidney to conduct away any urine if there happens to be leakage. Both the cigarette drain and the catheter are brought out at the upper portion of the wound and the wound is closed in the usual manner. The catheter is connected to a bottle to prevent soiling of the dressing, and if there is much infection in the pelvis of the kidney the catheter is kept in position as long as necessary for local medication. In this manner we have the advantage of the incision through the pelvis, together with drainage of the pelvis, but without the prospect of a prolonged fistula which may occur if the drainage is inserted into the wound in the pelvis. At the same time the catheter introduced in the manner indicated causes

to prevent crushing it. When the stone is too large to be brought through the pyelotomy opening, it may be broken purposely if one is careful to remove all fragments.

An x-ray equipment at the table for the purpose of taking pictures of the exposed kidney is helpful in removing fragments or multiple stones.

If fragments are left behind they may form a nucleus for another stone, so it is important to remove the calculus intact. After extracting the stone the pelvis is explored with the little finger if the opening is too small to admit the index finger, but the exploration should be as gentle as possible because the finger can easily rupture veins about the calyces that will cause considerable hemorrhage.

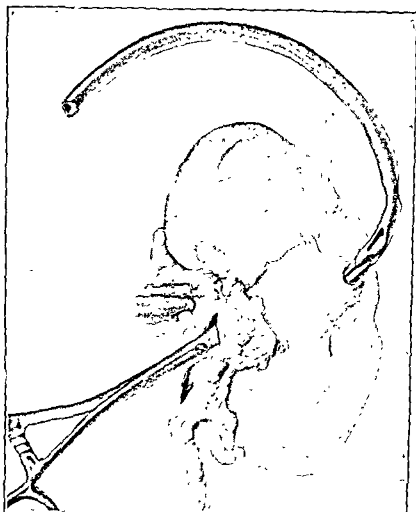


Fig 946 —The pelvis of the kidney has been opened and a forceps is thrust through to the cortex, where it grasps a soft rubber catheter

The next step of the operation depends on whether the pelvis of the kidney is to be drained. The great objection to pyelotomy is that if a drainage tube is placed into the pelvis of the kidney the fistula that results is sometimes very slow in closing Many operators practice suturing the pelvis without drainage when there is no demonstrable infection As the stone is often the result of infection and is frequently accompanied by infection even though it is mild, it seems that drainage as a rule would be beneficial Drainage of the pelvis of the kidney is best provided by inserting a small blunt pedicle forceps through the wound in the pelvis and thrusting it up through the substance of the kidney toward the middle point of

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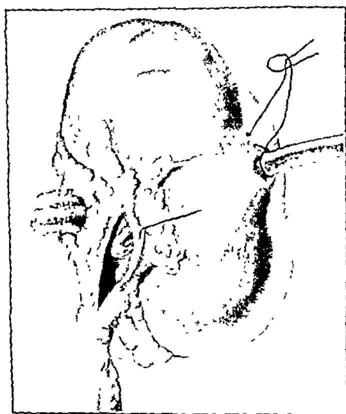


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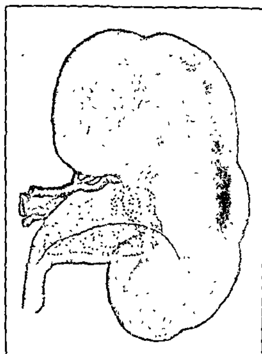


Fig 948

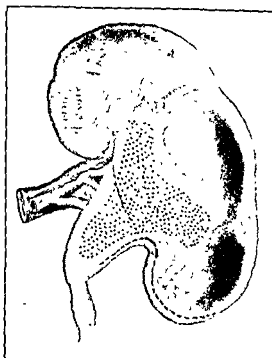


Fig 949.

Fig. 948.—The enlarged wound which is made through a relatively vascular portion of the kidney gives adequate room for the removal of large stones from the kidney pelvis The wound in the kidney is closed with interrupted sutures of No 1 chromic catgut and the wound in the pelvis with a finer suture of the same material

Fig 949—Dotted line indicates extension of the incision in the pelvis through the cortex opening the lower calyx of the kidney.

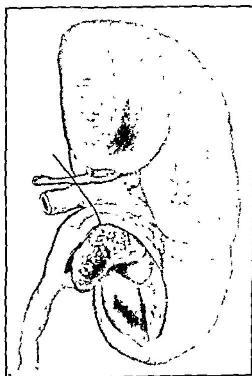


Fig 950—Curved incision for enlarging the wound in the pelvis by opening the lower calyx on the posterior surface of the kidney The wound is closed as in Fig 954

almost no destruction of the renal parenchyma and only a very small amount of bleeding. Usually there is no leakage around the catheter and the wound can be kept dry.

Jolly describes two methods of extending the incision from the pelvis into the renal cortex when the ordinary pelvic incision is too small. He credits Marion with enlarging the opening by continuing the pelvic incision into the cortex posteriorly. The incision begins on the posterior surface of the pelvis near the ureteral junction and curves upward toward the junction of the middle and lower thirds of the renal notch. Two clamps are then placed on the edges of the renal sinus to control the retropelvic vessels and the incision is continued through the kidney substance in the line of the lower calyx (Fig. 948). The incision gives ample room to explore the entire renal pelvis and is particularly suitable when the stone involves the pelvis and lower calyx. Only a slight thickness of renal tissue is involved and in a relatively nonvascular area. There is the disadvantage of dividing the retropelvic artery. The artery varies greatly in size and when small it may be divided without seriously interfering with the nutrition of the kidney. It is Jolly's opinion that the incision should not be made if the vessel is large enough to be felt pulsating when the posterior lip of the sinus is palpated. We have used this incision in one case with excellent results. Six months later the kidney showed marked improvement in function. After the stone is removed, a small tube is inserted, the posterior vessels are ligated, and the incision is closed, using interrupted sutures in the cortex and a continuous suture in the pelvis.

Inferior nephropyelolithotomy, as suggested by Zukerkandl, has lately been reviewed by Papin and by Zondek independently. In this operation, after the kidney is freed, the lower pole is lifted upward and an incision is made along the lower border of the pelvis. When the incision reaches the renal sinus, it is continued through the kidney substance, along its inner border to the lower pole (Fig. 949). The inferior border of the pelvis and the lower calyx are opened; this gives ample space for the removal of rather large stones and exploration of the pelvis and calyces (Fig. 950). It is particularly useful in the removal of large triangular stones which do not project into the calyces. Bleeding is relatively slight. The wound is closed as in the above-mentioned procedure.

In some cases it is advisable to combine pyelotomy with nephrotomy. This procedure is indicated when stones in the pelvis are associated with stones in the calyces too large to be removed through the mouth of the calyces without lacerating the kidney. The pyelotomy is done in the usual manner and after extracting the stones from the pelvis, the index finger is inserted into or against the mouth of the calyx and a short incision is made through the kidney directly over the stone. The wound in the cortex is closed with one or two interrupted sutures of catgut.

## HYDRONEPHROSIS

The surgical treatment of hydronephrosis consists of nephrectomy and of operations designed to improve the drainage of the kidney. No one method of treatment can be prescribed for all cases. The removal of obstructive lesions from the bladder or urethra relieves renal dilatation from that source, but obstruction in the upper urinary tract is a more difficult problem which should be recognized and treated before noticeable atrophy of the kidney has occurred. If one kidney is decidedly and permanently damaged and the other is normal, nephrectomy should

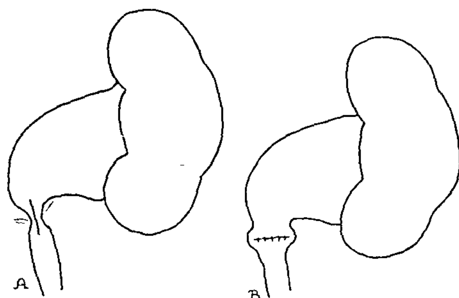



Fig 951.—*A*, Plastic operation for correction of short stricture of ureteropelvic area A longitudinal incision is made through the strictured area *B*, The longitudinal incision is sutured transversely, thereby enlarging the lumen

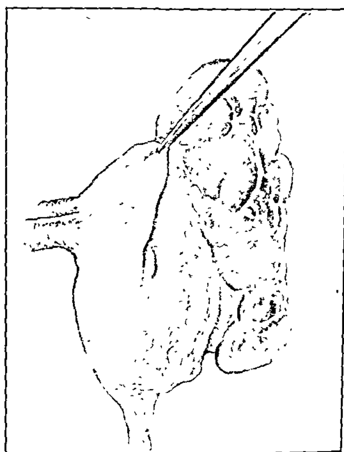


*Fig 952—The redundant kidney pelvis is dissected free and adhesions are separated from the upper portion of the ureter*

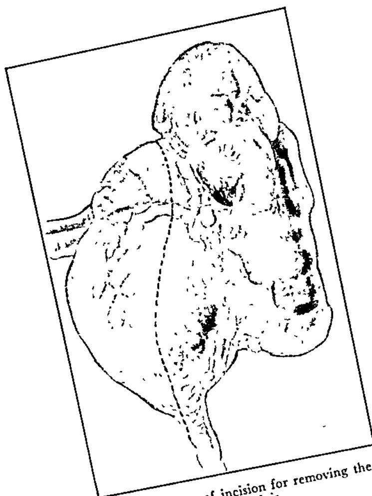


Fig 953 —Dotted line indicates the line of incision for removing the redundant portion of the kidney pelvis



Fig 954 —The wound in the pelvis is closed with a continuous suture of 0 chromic catg
The pelvic mucosa is not caught in the suture when it can be avoided.

be done. If the opposite kidney is inadequate, or if the dilatation is bilateral, treatment must consist of such measures as dilatation of the ureter, the removal of a stone, or plastic operations on the kidney or ureter.

Operative procedures for the direct treatment of hydronephrosis consist of the division of aberrant vessels and adhesions obstructing the upper ureter, of plastic work designed to improve drainage, and of operations for the reduction of the size of the hydronephrotic pelvis. Frequently, a combination of two or more of these procedures is necessary.

Short strictures at the ureteropelvic junction may be treated by a straight incision through the stricture. The ends of the incision are approximated and the incision is sutured transversely (Heineke-Mikulicz) (Fig. 951). The method advocated by Foley consists of a Y-shaped incision at the strictured area, which is sutured so as to make a "V," thereby eliminating the stricture. An operation similar to a Finney pyloroplasty is useful in longer strictures at the ureteropelvic junction and in cases in which the ureter enters the pelvis above the most dependent portion. In this operation one arm of the incision is in the ureter and the other in the adjacent portion of the kidney pelvis. The edges of the ureteral incision are then sutured to the adjacent edges of the incision in the pelvis.

Reduction in the size of the hydronephrosis may be accomplished by plicating the redundant pelvis, or by excising the excessive tissue and suturing the edges to form a pelvis of normal size. These operations are not often indicated Adequate drainage can usually be obtained by correcting obstructive lesions with or without nephropexy. However, when the excessive size of the pelvis interferes with drainage or when there is no demonstrable cause for the hydronephrosis, especially in bilateral disease, reduction in the size of the pelvis is beneficial. Plication of the renal pelvis is applicable only when its walls are quite thin Mattress sutures of fine catgut are placed in the fibrous coat of the pelvis in such a way that when they are tied, the pelvis is folded upon itself.

In pyelectomy the surrounding fat is carefully separated from the pelvis (Fig. 952), the upper ureter is isolated and the redundant portion of the pelvis excised with scissors (Fig 953). Care should be taken to excise the pelvis in such a way as to leave the ureter attached and in a dependent position (Figs. 953 and 954). It is necessary occasionally to excise the ureter and reimplant it into the pelvis. In all plastic operations on the kidney pelvis the kidney should be drained by a nephrostomy.

In plastic operations at the ureteropelvic junction and when the ureter is reimplanted into the pelvis, it is well to splint the area with a catheter placed in the ureter and brought out through the cortex of the kidney. The splint is removed in about a week and the nephrostomy tube should remain for at least two weeks In all plastic operations on the kidney pelvis fine chromic catgut should be used The suture line should not include the mucous membrane, but care should be taken in approximating the incision closely. When the ureter must be reimplanted into the pelvis, the end should be beveled to increase its circumference and sutured to an aperture in the most dependent portion of the pelvis by interrupted sutures of fine catgut It is well to buttress the sutures by a tag of fat.

## OPERATIONS UPON THE ADRENAL GLAND

Diseases of the adrenal glands have aroused increasing interest in recent years, and in some instances surgical intervention has been beneficial. Some forms of

precocity, pseudohermaphrodism, and hirsutism are considered clinical evidence of cortical hyperactivity or of tumors arising from the adrenal gland. Acute and recurrent attacks of hypertension have likewise been attributed to excessive adrenal activity.

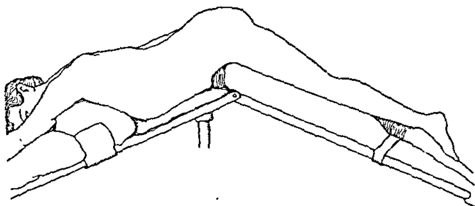


Fig. 955.—Position of patient upon the table for simultaneous exposure of the adrenal glands

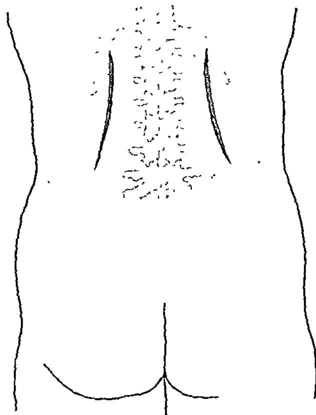


Fig 956 —Incisions for exposing both adrenal glands simultaneously.

The adrenal gland may be approached by an incision similar to that for exposure of the kidney. By extending the incision a little farther back and retracting the kidney downward, the adrenal gland is adequately exposed. It is often desirable, however, to expose and examine both adrenal glands before removing a part or all of either gland, for it may be impossible to determine preoperatively the location of a small tumor, or whether a hyperplasia is unilateral or bilateral. Transperitoneal palpation of the opposite adrenal gland is unsatisfactory, particularly in obese patients Delay is caused by the necessity of changing the patient to the opposite side so that the other adrenal may be exposed and examined.

An excellent method for the simultaneous exposure and study of both adrenals has been described by Young. The patient is placed upon the table, face downward, with a pad beneath the chest and another beneath the pelvis and lower extremities (Fig. 955). An incision is made first on the right side of the back, beginning 6 cm. from the spine and 3 cm. above the last rib. It extends downward and outward to a point 8 cm. from the median line to the crest of the ileum (Fig. 956). The incision is carried through the fat and fascia, to the latissimus dorsi muscle, which, together with the serratus muscle beneath it, is divided. The serratus magnus muscle is divided up to the eleventh rib, thereby exposing a large area of the costovertebral ligament. The conjoined portion of the lumbodorsal fascia

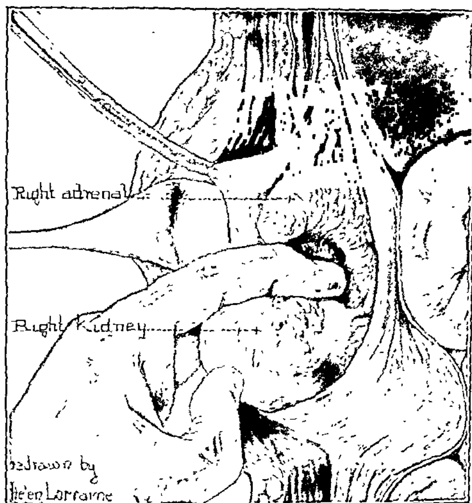



Fig 957.—The adrenal gland is being brought into view by traction on the upper pole of the kidney

is then incised just external to the outer border of the sacrospinalis muscle. By blunt dissection the tissues are then freed from the undersurface of the costovertebral ligament. By dissecting somewhat toward the spinal column there is less danger of injuring the pleura. The costovertebral ligament is then divided for at least 4 or 5 cm liberating the twelfth rib and permitting it to be drawn outward and forward. An excellent view is afforded the structures beneath. The retroperitoneal fat is stripped off, exposing Gerota's fascia. This fascia is stripped away from the quadratus lumborum muscle and divided near the upper pole of the kidney, exposing the kidney below and the adrenal gland above. The adrenals are

held in close apposition to the upper poles of the kidneys by the dorsal veins which come off from the renal pedicle. By downward and outward traction on the upper pole of the kidney and with the assistance of clamps on the fascia, the gland is drawn toward the surface of the wound (Fig. 957). The gland may now be stripped

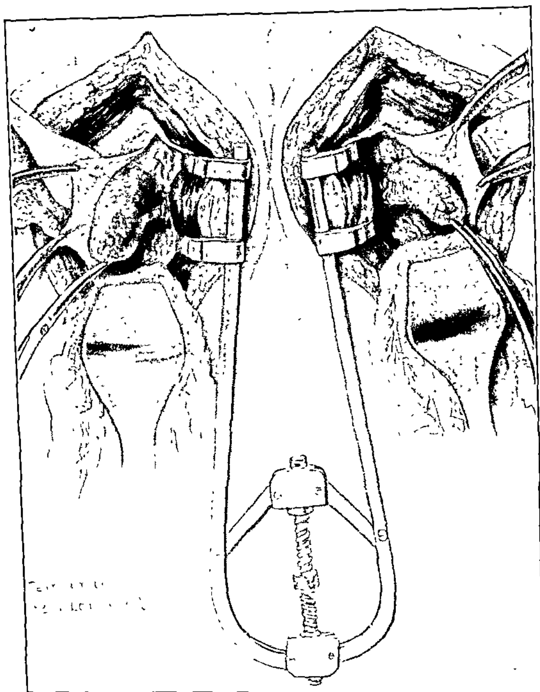


Fig 958.—Bilateral exposure of the adrenal glands for comparison and operation The exposure is greatly improved by the use of Young's retractor.

free of fat and adhesions and carefully examined for the presence of pathologic conditions. It is Young's opinion that even though a lesion exists in one adrenal, it is wise in most instances to expose the opposite adrenal before carrying out any operative procedure upon the gland. The left adrenal may be exposed by an assistant while the operator is exposing the right. Both adrenals having been satisfactorily

exposed, a retractor especially designed for this work is introduced. By a double-acting screw the retractor blades which slide upon lateral bars are made to compress the spinal muscles on each side, considerably enlarging the wound. The adrenal glands are then compared and further operative procedure is decided upon (Fig. 958). Small tumors may be shelled out, an entire gland or a portion of both glands removed, or the glands may be denervated. When the operation is completed, all bleeding points are ligated, a small cigarette drain is placed in the wound to emerge at the upper angle, and the wound is closed in layers.

Postoperatively the patient is kept flat in bed with such supportive measures as 5 per cent solution of dextrose in Ringer's solution, Adrenalin, and blood transfusions when necessary to control the fall in blood pressure and rapid pulse th-- may be at times disturbing.

## THE URETER

Operations upon the ureter consist in incising a stricture, in delivery of a stone, in suturing a wound in the ureter, in uniting the ureter when divided, in transplanting it, and occasionally in resection of the ureter.

The incision for exposure of the upper end of the ureter is practically the same as that for the lumbar operation upon the kidney. If it is not considered necessary to free the upper pole of the kidney, the incision need not be quite so high. The incision is carried downward and forward beyond the crest of the ilium, giving easy access to the upper third of the ureter The lower two-thirds of the ureter are best approached through a muscle-splitting incision similar to that for appendicitis and located over the lesion. The upper incision is described in the operation for exposure of the kidney, while a detailed description of the lower incision is given in discussing operations for stone in the ureter.

Strictures of the ureter are treated with bougies and catheters passed through the cystoscope. It is usually possible to dilate thoroughly the stricture and relieve the symptoms in this way. When the stricture is at the orifice it may be split with scissors or a fulgurating wire may be introduced through the cystoscope. Occasionally a dense organic stricture or one resulting from adhesions constricting the ureter or binding it down will not respond to cystoscopic dilatation These may be attacked through an extraperitoneal incision Freeing the ureter and liberating the adhesions may be all that is needed. If an organic stricture is present, the ureter is opened just above the stricture and dilatation is done from within.

A very good method is to pass a small ureteral catheter or bougie up the ureter to the stricture, and then the ureter is exposed extraperitoneally and opened about 2 cm. above the stricture The ureteral catheter is grasped, drawn through the wound in the ureter, and attached to the tip of a No. 14 French rubber catheter. After dilating the stricture the ureteral catheter is withdrawn, pulling the rubber catheter down through the strictured area until its tip presents beyond the urethral meatus. It is then drawn down until its upper end is just at the incision in the ureter. The wound in the ureter is closed with fine catgut, leaving a cigarette drain down to the ureter for forty-eight hours. The catheter is withdrawn in three or four days.

If the stricture is extensive with a large amount of fibrous tissue, it may be desirable to excise it and unite the ureter by an end-to-end anastomosis.

*In operations for stone in the ureter* the stone is localized by roentgen rays, the ureteral catheter, or by both, and an incision is made at a point where the stone will be most accessible. Frequently the stone is found in the ureter just as it crosses the brim of the pelvis or farther down just as it enters the bladder, as these are points of natural constriction of the caliber of the ureter. The incision may be made as a muscle-splitting incision as in the McBurney operation for appendicitis, only the muscles are split more widely than in the appendicitis operation (Figs. 959, 960). Better exposure is obtained by incising the aponeurosis of the oblique muscles downward along the margin of the rectus muscle. When the peritoneum is reached, it is not incised but is stripped up (Fig. 961). This is readily done with dry gauze on a sponge forceps, the stripping being toward the midline. A long retractor is inserted toward the midline and the iliac arteries are demonstrated.

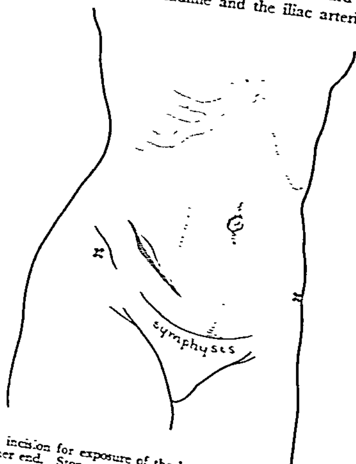



Fig. 959.—Skin incision for exposure of the lower end of the ureter. The incision may be extended from either end. Stones in the extreme lower end of the ureter are reached more readily by an incision near the margin of the rectus muscle.

The ureter practically always adheres to the peritoneum and is recognized as a band. If a good light is obtainable and the ureter can be watched for a moment, peristalsis will often be seen. The ureter may be dilated above the stone. The stone can frequently be felt and the ureter thereby is readily recognized. When the peritoneum has been stripped up as far toward the spine as can be readily done, the ureter will be found adherent to the peritoneum and just external to the line of attachment of the peritoneum to the spine.

Calculi located in the terminal portion of the ureter may be approached by a median suprapubic incision or by an incision along the outer border of the rectus muscle. In either case the peritoneum is not opened but is separated and retracted

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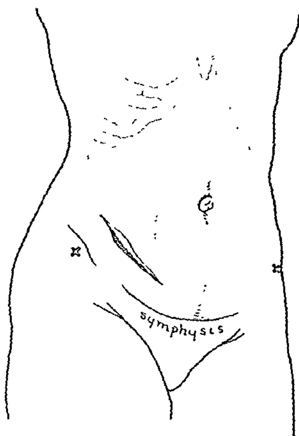



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toward the midline and dissection is continued down the side of the bladder into the pelvis. It may be necessary to divide some of the vessels of the bladder wall. As the dissection follows along the bladder, the vas deferens may be encountered as it courses around the bladder wall and passes between the bladder and ureter. It thus serves as a guide to the ureter, which lies along the pelvic fascia just below the lateral ligaments of the bladder.

After the stone is located, the ureter is isolated by blunt hooks or by passing a stout catgut ligature around it without tying the ligature. The ureter is brought toward the wound. It should not be dissected any freer from the surrounding tissues than is necessary to obtain access to the stone.

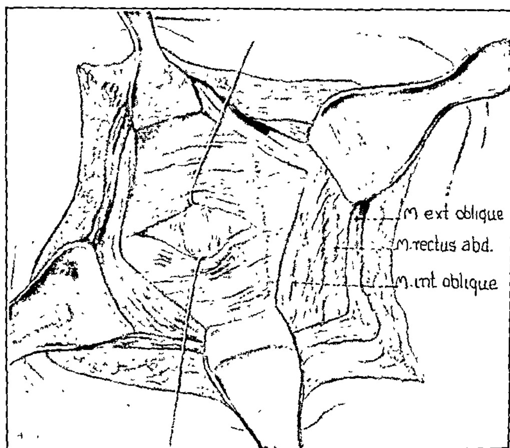



Fig. 960—Exposure of the ureter The incision is made over the portion of the ureter to be exposed and the muscles are divided in the direction of their fibers When more room is needed, the aponeurosis of the external and internal oblique muscles may be divided near the margin of the rectus muscle If they are carefully sutured, the wound will heal firmly.

Stones low in the pelvis may sometimes be milked upward to more accessible location, making removal easier and avoiding an extensive stripping of the ureter from its bed

After protecting the surrounding tissues with gauze packing a longitudinal incision is made over the stone, which is extracted It is best, as a rule, not to attempt to suture the ureter, though if the incision is unusually long a few interrupted sutures of fine chromic catgut may be placed They should not penetrate the whole thickness of the ureteral wall. A cigarette drain or a strip of rubber tissue is carried down to the wound in the ureter. If the wound in the ureter is in the pelvis, a soft rubber tube should never be used for drainage. Several cases are on record where the resting of a soft rubber tube on the iliac artery unprotected by

peritoneal covering has produced secondary hemorrhage by pressure necrosis on the artery. A cigarette drain or a strip of rubber tissue will hardly cause this. In extraction of a stone from the ureter above the pelvis, where the drainage will not be in contact with any large vessels, a soft rubber tube may be used.

Many ureteral stones can be removed with a cystoscope in the hands of an expert urologist. If this seems possible after the size and location of the stone have been determined, an effort should be made to extract the stone in this manner before resorting to operation. Only one well trained in such work should attempt this, however, as it requires much skill and practice.

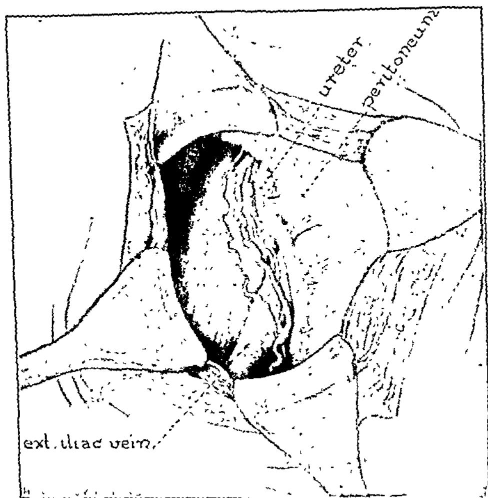



Fig. 961.—Exposure of lower ureter. The wound is retracted and the peritoneum is pulled toward the midline. The ureter is found loosely adherent to the peritoneum.

## Ureteral Anastomosis

The ureter is sometimes divided accidentally during operations in its neighborhood, particularly in extensive operations for malignant growths of the uterus. If the other kidney is sound, simple ligation of the ureter may be done and often this kidney becomes atrophied with but little or no pain and the other kidney takes up the work satisfactorily. If, however, there is any suspicion of the function of the opposite kidney, this should not be done. If it is possible to do so without too great risk to the patient, an effort should be made to re-establish the continuity of the ureter. Various operations have been devised for this purpose, but it has been quite clearly proved, particularly by the work of Payne, that all of the

methods of uniting a divided ureter are likely to be followed by stricture except the simple end-to-end method. This is logical because here the minimum amount of raw surface is apposed and consequently there is less scar tissue to cause later contraction.

If a satisfactory exposure can be had, the suturing together of a divided ureter is not a very difficult procedure. The sutures may be of very fine silk or preferably of fine chromic catgut. The objection to silk is that it may work into the lumen and as a foreign body form a nucleus for a stone. Three interrupted sutures are passed at equal distances around the circumference of the ureter and approximate the divided ends of the ureter in much the same manner as Carrel uses in suturing blood vessels. All of these sutures should be passed before any of them is tied. In this manner they can be simultaneously drawn taut and tied one at a time while the others are held taut, so keeping unnecessary strain from the suture that is being tied. The ends of the sutures are left long, the margins of the wound are whipped over with a continuous suture of fine chromic catgut in a fine curved needle while holding the three tractor sutures in such a manner as to render the part of the wound that is being sutured readily accessible and moderately tense. While suturing between two tractor sutures the third should be slightly pulled away to prevent the possibility of catching the opposite wall of the ureter in the sutures. The sutures should not be drawn too tightly, but just enough to secure accurate approximation. After the whole circumference of the divided ureter has been sutured, the ends of the tractor sutures are cut rather long and the ureter is returned to its bed.

The ureter should be incised about 2 to 3 cm. below the end-to-end union and a small catheter passed to the pelvis of the kidney and maintained in this position for about two weeks This lessens the tendency to stricture at the suture line of the ureter.

When a considerable portion of the ureter has been sacrificed, it is often difficult or impossible to approximate the ends of the ureter without too much tension.

Considerable additional length of the ureter can be made available by mobilizing and straightening both segments of the divided ureter. This can be done without danger, since the blood supply of the ureter is quite liberal. If anastomosis cannot be accomplished, the ureter may be ligated, transplanted to the sigmoid, or transplanted to the skin of the abdomen as conditions indicate. If the patient's condition will not permit ureterointestinal anastomosis, it is usually better to bring the ureter to the skin Final disposal of the ureter can be determined later.

## Transplantation of Ureter

In a contemplated excision of the bladder or in injury of the ureter near the bladder when direct anastomosis cannot be made, the question of the disposition of the ureter must be settled. There is a choice of four different methods:

1. The ureter may be tied, and, as has already been mentioned, the kidney will, as a rule, eventually atrophy and give no further trouble. This method may be used in emergencies when the patient is in shock or the condition is so grave as to demand the quickest procedure and when there is assurance that the ureter and kidney on the other side are normal. Such a method should be only exceptionally resorted to as the aim in surgery should be, first, to preserve life and, second, to preserve function It is only when these two aims are in conflict that function should be destroyed.

2. The ureter may be transplanted to the skin of the abdomen and a special apparatus used to collect the urine. This transplantation should be done extraperitoneally.

The ureter is exposed through an incision about an inch mesial to and extending a little below the anterior superior spine of the ilium (Fig. 959). The muscles are separated in the direction of their fibers. The peritoneum is detached and retracted to the midline, exposing the ureter which is attached to the peritoneum by loose fibrous bands. The ureter is identified and freed well up toward the lumbar region so that it can be displaced laterally and avoid traction resulting from attachment to the abdominal viscera. The ureter is divided as near the bladder as possible, and after ligation of the distal stump the liberated ureter is displaced laterally and brought through the abdominal wound near the lower angle. The ureter should be kept as straight as possible and without undue tension. The ureter is sutured to the margin of the wound with interrupted sutures of fine silk with about 2 5 cm. left protruding from the wound. The wound is closed loosely about the ureter and a soft rubber drain. A small rubber tube or catheter is then inserted through the ureter for drainage of the kidney.

Instead of doing this, the ureter may be ligated and a nephrostomy done according to the method of Cabot, using a special apparatus to collect the urine from the nephrostomy wound. Such procedures may be restored to where the function of the ureter is greatly impaired.

3 The ureter may be transplanted into the bowel. This may be necessary because of the extensive disease of the bladder or in exstrophy of the bladder.

4. The ureter may be transplanted into the bladder. This, of course, is the most desirable disposition of the ureter, but unfortunately it is not always possible. In resection of a portion of the bladder for malignant disease when the orifice of the ureter is involved, the ureter may be transplanted into the bladder with considerable assurance of a permanent preservation of the function of the kidney from which the ureter comes The same is true when the ureter has been accidentally severed near the bladder or must be divided in this area because of disease.

The technic of the operation will vary according to the problems to be met and to some extent according to the preference of the surgeon. The ureter can be transplanted successfully either transperitoneally or retroperitoneally. In the transperitoneal operation the peritoneum should be accurately sutured over the ureter and extraperitoneal drainage should be provided to the area of implantation. Transperitoneal implantation is the natural procedure when an injury of the ureter is discovered at the time of a pelvic operation. When operating to reimplant the ureter into the bladder because of disease or injury of the ureter or to reimplant the ureter following partial cystectomy, the extraperitoneal approach has several advantages: The ureter is more easily exposed and liberated. Both the ureter and the portion of the bladder presenting the most desirable location for reimplantation are normally extraperitoneal. Retroperitoneal drainage is more easily instituted and there is less danger of disastrous results from leakage or infection.

In all cases the cardinal principles of plastic surgery must prevail. The structures must be approximated absolutely without tension, and adequate blood supply must be preserved Infection must be prevented or controlled and the site of operation must be kept at rest. The site of the implantation and the way in which the ureter is made to traverse the bladder wall depend to some extent upon the

length of ureter available and in bladder resection upon the amount of bladder that must be removed. The implantation should be made into the base of the bladder near the original ureteral orifice when possible. Angulation at the point of entrance is less apt to occur, and subsequent catheterization, if indicated, will be less difficult. The ureter should be implanted near the top of the bladder only when it is necessary to prevent tension at the point of union. A submucous implantation following the principles advocated by Coffey is preferable (Fig. 962). This should not be attempted, however, unless the ureter is long enough to project well into the bladder after traversing the wall obliquely.

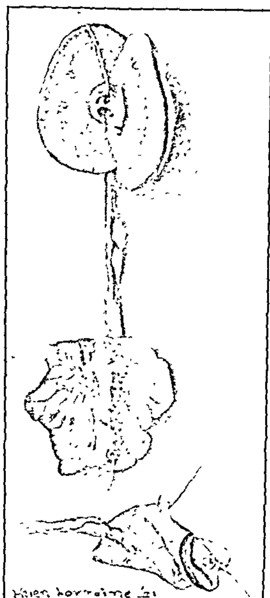


Fig. 962.—The Coffey method of transplanting the ureter into the pelvic colon. The ureter is carried obliquely through the serous and muscular coats and between the muscular coat and the mucous membrane for about an inch. This drawing was made from an autopsy specimen taken two months after transplantation of a dog's ureter. Note excellent condition of the kidney and ureter.

The additional length of ureter made available by mobilizing and straightening the ureter to lengthen it and to lessen the distance that it must traverse to reach the bladder is considerable. This is particularly true when the ureter has become dilated and tortuous because of partial obstruction which often occurs following

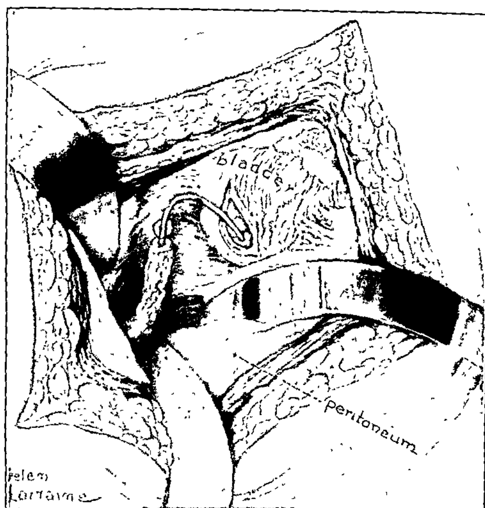



Fig 963—Small catheter inserted a few centimeters into the ureter and secured by a ligature to the beveled end of the ureter serves as a splint. (From Dodson: Some Improvements in the Technic of Ureterocystostomy, J Urol, March, 1946)

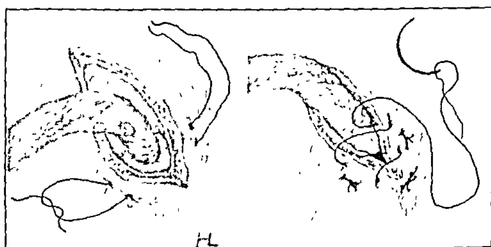


Fig. 964—Fixation sutures passed through superficial tissue of ureter and through the bladder wall secure the ureter in place (From Dodson Some Improvements in the Technic of Ureterocystostomy, J. Urol, March, 1946.)

area pierced by the sutures enters the bladder incision. The sutures are drawn taut and tied on the outside of the bladder as mattress sutures. The muscle and fascia of the bladder are fastened over the ureter from below upward with a continuous suture of 0 chromic catgut (Fig. 964). The last suture should catch a small piece of the superficial tissue of the ureter. A small rubber tissue drain is carried down to the implantation and brought out near the upper angle of the wound. A mushroom catheter is then inserted into the anterior bladder wall through a short incision, and a purse-string suture is placed around the catheter, making a watertight closure. The catheter is brought out near the lower angle of the wound. With a small catheter in the urethra and the large catheter placed suprapubically, complete drainage and absolute immobilization are assured. When the length of the ureter does not permit a submucous implantation, the operation differs only in that the ureter enters the bladder through a short incision directly through the bladder wall.

Ureterocolostomy

It may be necessary to transplant both ureters into the bowel in exstrophy of the bladder or where a malignant growth involves so much of the bladder wall as to render a radical operation impossible or to demand removal of the whole bladder. Ureterocolostomy should be preceded by a few days of preparation. In addition to thorough investigation of the urinary tract and general physical examination, particular attention should be given the colon. For about a week before operation, Sulfathalidine should be given for the purpose of reducing the bacterial content of the intestine. This should be supplemented by the oral administration of streptomycin during the final forty-eight hours. The diet should be liberal but of low residue. The bowels are evacuated daily by enema if necessary. During this period the patient may be ambulatory and not necessarily hospitalized. The afternoon before operation a thorough colonic irrigation should be given in addition to the usual preparation for abdominal surgery. The following morning a low enema is given and a small rectal tube left in place

If the ureters are to be transplanted separately into the sigmoid either for exstrophy of the bladder or for malignancy, the first operation is best done on the right side, making an incision slightly to the right of the midline, because the sigmoid is on the left and, if the operation on the left side is first done, it may be more difficult to mobilize the sigmoid in the second operation which must be on the right side. After exposing the sigmoid and determining the point at which the anastomosis should be made, particularly with regard to a subsequent operation on the left side, this point is fixed by clamping the sigmoid with a large curved intestinal clamp. The lower end of the ureter is dissected out and divided close to the bladder and the proximal end is split for 0.5 cm. In order to preserve the nutrition of the ureter, as in operations for transplantation of the ureter into the bladder, no more of the ureter is dissected free than is necessary for the purposes of the operation. The distal end of the ureter is tied and in exstrophy it may be buried in the tissues around it by a few catgut sutures. The peritoneum and muscular coats of that portion of the sigmoid in the grasp of the curved intestinal clamp are incised for about 4 cm. It is best to make this incision through the firm longitudinal bands in the wall of the sigmoid. The incision is carried down to the mucosa but not

through it. At the distal portion of the incision the mucosa is punctured and a fine chromic catgut suture which transfixes the tip of the ureter is threaded with a needle at each end, carried through this punctured wound in the mucosa, and penetrates the bowel 1 cm. distal to the punctured wound. Both needles are carried through a short distance from each other and the suture is tied, so fixing the ureter in its new position. The wall of the ureter is caught in the bite of a catgut suture just as it penetrates the mucosa, and the suture also catches a bite in the muscular and peritoneal coats of the sigmoid on each side. This suture is tied so as still further to fix the ureter in the wall of the sigmoid. The incision is closed by continuous sutures of fine chromic catgut, which buries the ureter on the mucosa. A valve is formed of the mucosa, which prevents back pressure. This method of Coffey tends greatly to diminish ascending infection of the kidney. By use of this principle of his, pressure within the bowel produces a valvelike effect on the mucosa and occludes the end of the ureter against the gas pressure within the bowel but at the same time does not produce sufficient pressure to prevent delivery of the urine into the bowel. The wound is closed without drainage or else with a small soft tube or rubber dam. The sphincter is dilated and a tube is inserted a few centimeters in the rectum for the first four or five days in order to facilitate the emptying of the urine until the bowel gradually becomes accustomed to it. The second ureter is transplanted about two weeks later if the patient is in good condition.

By the use of indwelling catheters, both ureters may be safely transplanted at the same time. This method, described by Coffey, is carried out in the following manner. The patient is given castor oil on two nights preceding the operation. On the night before and the morning of the operation, the colon is copiously irrigated A rectal tube is passed just before operation to drain off any retained fluid. The operation is done under general or spinal anesthesia. In adults spinal anesthesia is preferable because of the excellent relaxation.

The abdomen is opened through a liberal paramedian incision. The head of the table is lowered and the omentum and intestines are packed off with gauze above the true pelvis. A soft rubber-covered clamp is placed on the sigmoid at the brim of the pelvis. The patient's hips are then pulled to the foot of the table and an assistant passes a sigmoidoscope up to the intestinal clamp and withdraws the obturator. A large needle attached to an irrigating can is passed through the bowel into the open end of the sigmoidoscope and the instrument is withdrawn until the tip is just inside the anal canal. This segment of the bowel is irrigated with normal saline until the return flow is perfectly clear. About 500 c.c. of 1 per cent solution of Mercurochrome is then run through the needle. Rather than puncture the bowel with a needle, we have attached a catheter instead of a needle to the irrigating can and passed it up to the intestinal clamp through the sigmoidoscope to irrigate the bowel The bowel is then packed through the sigmoidoscope with a long strip of gauze The ureters are identified, dissected free for about 7 cm., ligated as near the bladder as possible, and divided near the ligature. The stumps are cauterized with pure carbolic acid. The proximal stumps are split for about 0.5 cm Two No 12 ureteral catheters prepared by placing a cuff of rubber tubing around them about 10 cm. from the tips are passed into the ureters up to the rubber cuffs The ends of the ureter are then pulled over the rubber cuffs and each ureter is tied to its catheter with two ligatures of 00 plain catgut, one over the rubber cuffs and one just above it. No. 7 catheters are adequate and less traumatizing. Two

incisions are then made, one about the junction of the rectum and sigmoid on the left side, passing from the junction of the colon and mesocolon downward and toward the midline at about an angle of 45° until the midline of the intestine has been reached. The incision is deepened until the mucosa can be seen bulging into the wound for the entire length of the incision. The muscular coats are stripped back with the handle of a knife. A similar incision is made on the right side of the bowel about 5 cm. below the lower end of the left incision. Stab wounds are then made in the lower angles of the intestinal wounds and a wisp of gauze from the packing in the rectum is pulled through each stab wound. With fine silk the lower

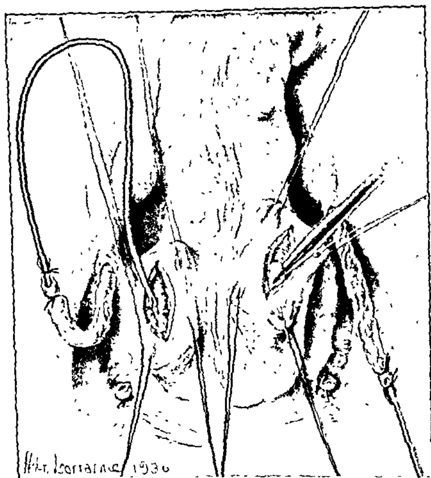


Fig. 965.—The Coffey operation of transplantation of the ureters into the large bowel. The intestines have been packed off and a clamp has been placed on the lower sigmoid. The rectum and a portion of the lower sigmoid have been irrigated and packed with gauze. Incisions have been made down to the mucosa, catheters fixed into the cut ureters, and gauze has been brought into the lower angle of the wound in the intestine. The free ends of the catheters are sutured to the gauze, which is withdrawn from the rectum, pulling the catheters and ends of the ureters into the bowel

ends of the catheters are sutured to the gauze (*Fig.* 965). The gauze is then gradually removed from the anus and the catheters are guided into the lumen of the bowel. As the catheters appear at the anus, they are grasped and pulled upon until the ends of the ureters are brought into the bowel for almost 2.5 cm. The remaining gauze is then removed from the rectum. In some cases the sigmoidoscope and the packing have been omitted. The bowel is irrigated with a two-way irrigating tube. The catheters are inserted through a nick in the bowel and pulled down by the finger of an assistant. When an assistant can easily reach the catheters, the

operation might be done quite as satisfactorily without the packing and with less trauma to the intestinal mucosa. Interrupted sutures of 00 chromic catgut are placed in the lower angle of the intestinal wounds, including the muscular layers of the intestine and a bite in the ureters. The wounds in the bowel are then sutured over the ureters with continuous sutures of 00 chromic catgut, approximating the

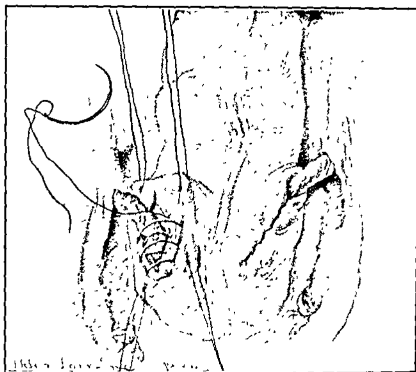


Fig. 966.—The ureters lying on the mucous membrane of the bowel are covered by the muscular and peritoneal layers which are sutured with two layers of continuous sutures of 0 chromic catgut

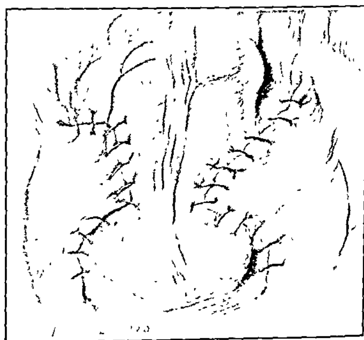


Fig 967 – The completed operation Flaps of parietal peritoneum from the margin of the wound made to expose the ureters have been sutured to the bowel, entirely covering the wounds in the bowel

peritoneal surface (Fig. 966). The flaps of parietal peritoneum which had covered the ureters are brought over and sutured to the bowel in such a way as to protect the area of the transplantation (Fig. 967). The abdomen is closed without drainage. In none of our cases has there been any evidence of infection at the site of the anastomosis, while in one case intestinal obstruction developed, probably as a result of drainage. The catheter technic of Coffey has the advantage that it is a one-stage procedure and the function of the kidneys is not interfered with by obstruction for the first few days after operation. Most surgeons now prefer to transplant both ureters without catheters. The danger of temporary occlusion is of little consequence.

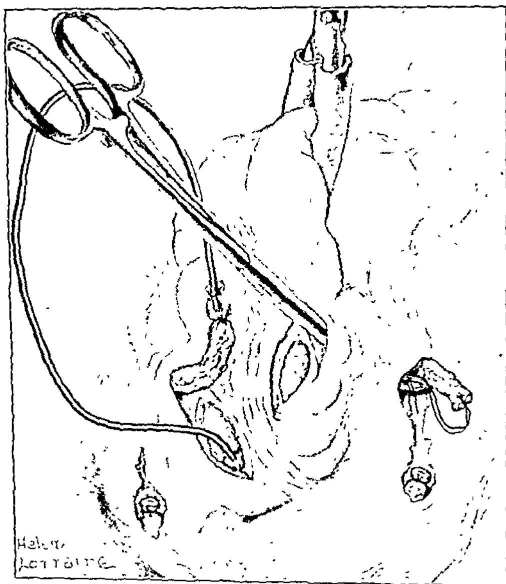



Fig. 968.—Transplantation of ureters into large intestine. Two incisions have been made in the bowel down to the mucosa. The ureters are carried retroperitoneally to these incisions. On patient's right an ureteral catheter has been inserted in the ureter up to the pelvis of the kidney. It is secured to the ureter by two ligatures and the distal end is being passed through a small incision in the lower angle of the intestinal wound.

Coffey's operation has been modified in the following manner: After the incisions have been made in the sigmoid and the ureters have been exposed and divided, the parietal peritoneum is dissected up from the upper angle of the intesti-

nal wounds to the ureter. A hemostat is passed behind the peritoneum and the end of the ureter is grasped and drawn through (Fig. 968). The ureters are sufficiently freed retroperitoneally to permit them to enter the intestinal incision without angulation. After completing the transplantations the incisions in the parietal

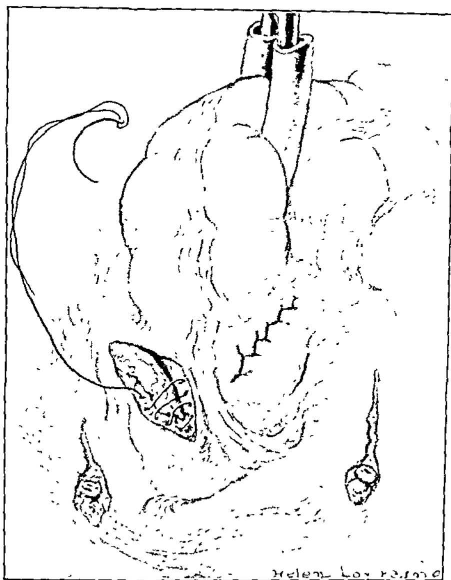


Fig 969—On patient's right the ureter has been pulled through the nick in the mucosa at the lower angle of the intestinal wound and fixed by an interrupted suture to the musculature of the bowel A right angle continuous suture is being placed in the muscular layer, the first step in covering the ureter On the patient's left a second row of continuous sutures has been taken in the peritoneum, closing the incision The incisions for exposure of the ureter will be closed likewise.

peritoneum are closed by continuous sutures of 0 chromic catgut The operation takes less time, the ureters are left in more natural position, and the sigmoid is not fixed by the suturing of flaps of parietal peritoneum to its anterior surface (Fig 969)

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# CHAPTER 71

# THE BLADDER AND URETHRA

Austin I. Dodson

## THE BLADDER

Surgery of the bladder consists chiefly of the resection of ulcers or malig growths, excision of diverticula, and cystotomy for drainage or for the extrac of foreign bodies Benign growths in the bladder and small ulcers are treated cessfully by fulguration, and many stones may be crushed and removed by lithotrite. Previous to any operation on the bladder it is desirable that a thor cystoscopic study be made to determine accurately the character and locatio the lesion If the bladder is infected, a preliminary course of irrigations and insi tions of antiseptics will insure a much smoother convalescence after operation

### Suprapubic Cystotomy

Approach to the bladder for resection of the bladder wall, diverticulect for stone or for drainage is frequently indicated. Where the bladder wall is t operated upon, it is well to map out the involved region by cystoscopic study vious to operation. This operation of suprapubic cystotomy may be exceedi simple when the bladder is distended or capable of being distended, or it ma difficult if the bladder is thick and contracted. Where it is possible to do so, best to distend the bladder with some mild antiseptic solution, such as boric solution, just before the operation. A soft rubber catheter is inserted into the b der and the warm boric acid solution is gradually introduced by gravity until bladder is filled. If the irrigating can is not more than two feet above the lev the patient's body, it is hardly possible for the bladder to be damaged by the irr tion The catheter is left in position The bladder should never be filled l piston syringe, as several cases are recorded in which an apparently low degre pressure with such a syringe ruptured the bladder. If gravity is used slowly carefully, such an accident is impossible. It must be borne in mind, however, in manipulating a well-filled bladder strong pressure upon it may cause it to : ture An incision is made in the abdominal wall, usually a longitudinal incis and after separating the fibers of the recti and pyramidalis muscles the fascia im diately beneath them is incised and the prevesical fat exposed. The peritoneal in the upper portion of the wound is recognized and gently stripped upward v gauze If it is opened it may be immediately sutured without danger The fa divided down to the anterior wall of the bladder and is then pushed to the side downward into the space of Retzius The thin layer of fascia adherent to the

terior wall of the bladder is divided transversely (Fig. 970) and the lower flap dissected and sutured with two or three interrupted sutures of plain catgut to muscle at the lower angle of the wound, thereby securely closing off the space of Retzius (Fig. 971). It is well to place a small gauze pack at the upper angle of the wound in order to protect the peritoneal cavity from being accidentally opened while enlarging the incision. If the condition of the bladder has previously been determined by cystoscopy or cystogram, and the operation is done for drainage of the bladder, we place a purse-string suture of chromic catgut in the bladder wall (Fig 971). After the bladder has been emptied with a catheter, a small incision is made within the confines of the purse-string suture, through which a drainage tube is inserted. The purse-string is drawn taut, securely protecting the suprapubic wound from contamination (Fig. 972). The ends of the purse-string suture are left long and passed through the margins of the abdominal muscles and fascia securing the bladder to the abdominal wall.

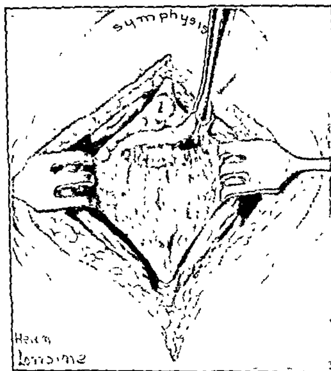



Fig. 970.—Suprapubic cystotomy The skin and fascia are incised and the recti muscles separated, exposing the anterior wall of the bladder, which has previously been distended with an antiseptic solution. The thin fascia and fat are divided transversely and the lower flap is stripped downward

If the operation is done merely for drainage and exploration, a short vertical incision that will admit the finger is all that is necessary, but if a large tumor is to be removed a more ample exposure is required. Here the incision in the bladder wall should be transverse, keeping along its apex and as close to the peritoneal fold as seems safe If it goes down into the space of Retzius and near the urethral opening, it is difficult to suture and to heal. The bladder wall, having been recognized, may be fixed either by two Allis forceps or by two sutures of catgut or silk inserted with a round curved needle. The fluid is then drawn off through the catheter in the urethra and the bladder is incised between the two forceps or sutures. In this way the prevesical tissues are not flooded with the vesical contents and infection is less

likely to occur. Where the bladder is distended from an impermeable obstruction, the urine may be drawn off by thrusting a trocar and cannula through the bladder wall which is incised after withdrawing the trocar and cannula. It may ocasionally be difficult to recognize the bladder wall if not distended, but when filled with fluid

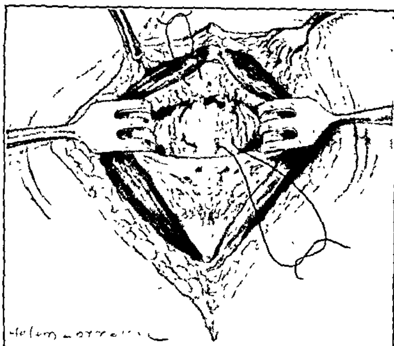


Fig 971.—The fascia and fat are sutured to the muscle in the lower angle of the wound, sealing off the space of Retzius, and a purse-string suture is taken in the anterior bladder wall

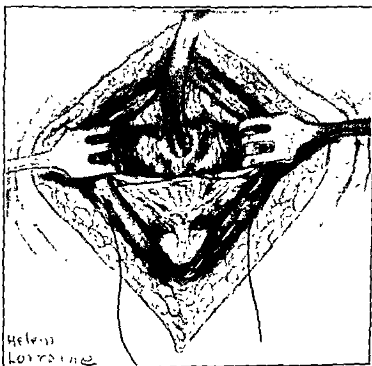



Fig 972—A stab wound has been made within the confines of the purse-string suture, a drainage tube inserted, and the suture drawn taut and tied The ends of the suture are threaded in needles and carried through the muscle and fascia of the abdominal wall When tied, they secure the bladder to the abdominal wall If the bladder is to be explored or an operation performed within the bladder, a transverse or vertical incision is made to open the viscus

it is easily identified. After the bladder has been opened, the incision is extended for better exposure, or the stone is extracted, or drainage instituted, according to the indications. If the incision in the bladder wall is short, a drainage tube is brought out at the upper portion of the incision and the lower margin of the wound is closed with catgut sutures. These sutures in a short wound are interrupted, of chromic catgut, and take either none of the mucosa or as small an amount of it as possible. In a larger bladder wound the two layers of sutures that have been mentioned are the best method of closing the wound. Bleeding in the bladder wound is controlled by whipping over the bleeding spot with small plain catgut in a round noncutting needle.

If a suprapubic cystotomy is done with the bladder collapsed, the abdominal incision is the same as when the bladder is distended, but the vesical wall is much more inaccessible. Having the patient in the Trendelenburg position is a great help. Dissection is carried down to the pubic bone and then the prevesical fat is cut through until the bladder is demonstrated. After it has been recognized, it is incised and the operation is finished in the usual manner. If a sound or a catheter can be introduced into the bladder, usually it can be distended, but careful dissection without a sound will, as a rule, expose the bladder wall without much difficulty.

With an impermeable stricture or a prostatic obstruction it is sometimes impossible to enter the bladder with an instrument through the urethra. These patients are often poor surgical risks and it is necessary to evacuate the urine by as simple a process as possible. Here a puncture with a trocar and cannula is usually safer than suprapubic cystostomy. A trocar and cannula are selected so that the trocar can be removed and a small soft rubber catheter is threaded through the cannula into the bladder. The trocar and cannula should be of such a type that the urine can be drawn off through a lateral projection near the end of the cannula. Before the operation the catheter is tested to see that it will go through the cannula easily. The skin of the abdomen is infiltrated with procaine solution, and an incision of 1 cm. is made just above the pubis and close to the pubic bone. The deeper tissues are infiltrated, a proper trocar and cannula are grasped firmly and thrust quickly into the bladder in a direction inward and upward. Of course this is never done except when the bladder is fully distended. If the trocar and cannula go straight inward the prevesical space may be injured, the trocar will sometimes cut the bladder wall obliquely, and if there is a large prostate it may not enter the bladder at all. By directing the thrust upward as well as inward this accident to the prevesical space is avoided, and there is no danger of injuring the peritoneum if the bladder is distended, provided the entrance point in the abdominal wall is just above the pubic bone.

If one is in doubt, a small caliber needle may be introduced and aspirated. The appearance of urine will indicate the proper location of the needle. The needle is withdrawn and the trocar and cannula are immediately thrust through the same area in the same direction. When the instrument is felt to enter the bladder, the trocar is removed and a catheter which has been previously fitted to the cannula and in which an extra eye has been cut is inserted. A free flow of urine from the catheter indicates that it has entered the bladder. The catheter is pushed toward the bladder as the cannula is withdrawn over it. If it is desired to empty the bladder gradually, a rubber tube is fitted over the lateral outlet of the cannula and clamped. A catheter which fits the cannula snugly and has been closed at the distal

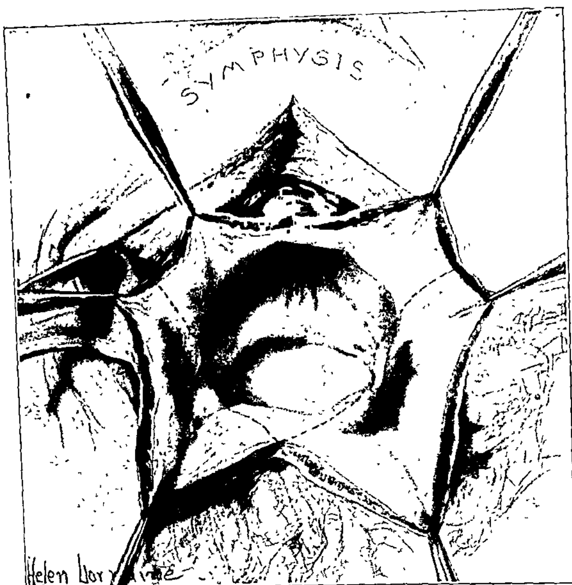



Fig 973 —Operative exposure of the bladder for resection of multiple Hunner's ulcers. Dotted line shows line of excision

## Tumors of the Bladder

Tumors of the bladder may require operation Many tumors, particularly the benign papillomas, are cured by fulguration, and radium in some cases is beneficial. If the tumor is malignant and involves a considerable portion of the bladder wall, and particularly if it does not readily respond to fulguration or radium, operation is the best method of treatment. If the growth has a distinct pedicle, the mucosa can be excised around the pedicle with a cautery, but usually the resection should include the whole thickness of the bladder wall, going some distance beyond the apparent margins of the growth into what seems to be healthy tissue. Excision of the total thickness of the bladder wall is no more difficult than excision of a portion of the wall and is more likely to result in cure. If the growth involves the part of the bladder that is covered with peritoneum, the peritoneal cavity is opened and packed off and the diseased section is removed (Fig. 974). If, however, other portions of the bladder are involved, the operation should be done extraperitoneally if possible. Most tumors of the bladder originate in the base of the bladder and many of these involve one of the ureteral openings, so that excision of this section of the bladder

may involve transplantation of the ureter, or else ligation of the ureter if the remaining kidney is healthy and it is impossible to transplant the ureter. Occasionally, both ureters require transplantation.

Whether the peritoneal cavity is opened or not, the patient is placed in the Trendelenburg position and good exposure is obtained by a long incision in the bladder. Care is always taken to protect the prevesical space by packing it with gauze.

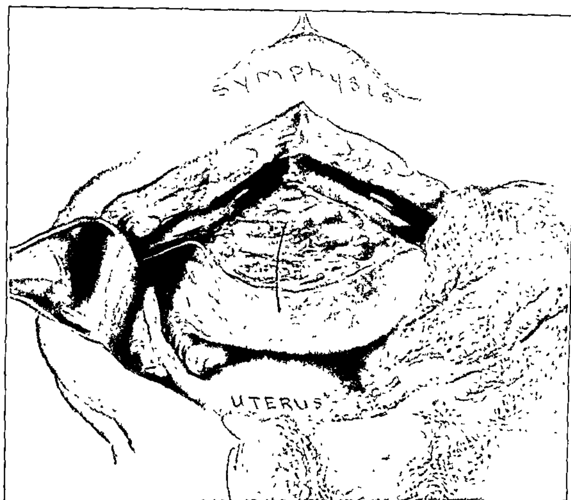



Fig 974 —Incision for exposing the bladder for radical resection of cancer involving the posterior wall or base of the bladder.

The excision of the bladder wall is made with an electric cautery or radio or endotherm knife wherever possible (Fig 975). The bladder wound is closed with two layers of chromic catgut sutures, the inner layer catching as little as possible of the mucosa (Fig. 976). The outer layer is inserted through the muscular coat only and like the inner layer is a continuous suture. Drainage is always placed either through a portion of the incision, preferably as close to the peritoneal fold as possible, or the incision may be closed completely and drainage instituted through a stab wound at about the apex of the bladder and 2 cm. or more from a sutured incision. If it is necessary to dissect the space of Retzius extensively, a gauze cigarette drain is placed to the bottom of this space in addition to the drainage in the bladder.

## Total Cystectomy

Total excision of the bladder is indicated in cases of carcinoma so situated or so extensive that there is no probability of a cure by radiation or by excision of the

growth. Disposal of the urine must be provided for by bringing the ureters to the surface of the abdomen where the drainage is collected in a urinal, or by transplantation into the sigmoid. In most cases it is safer to transplant the ureters at an earlier operation, removing the bladder when the patient has sufficiently recovered. Beer, who preferred anastomosis of the ureters to the skin, stated that both operations could be safely done at one time.

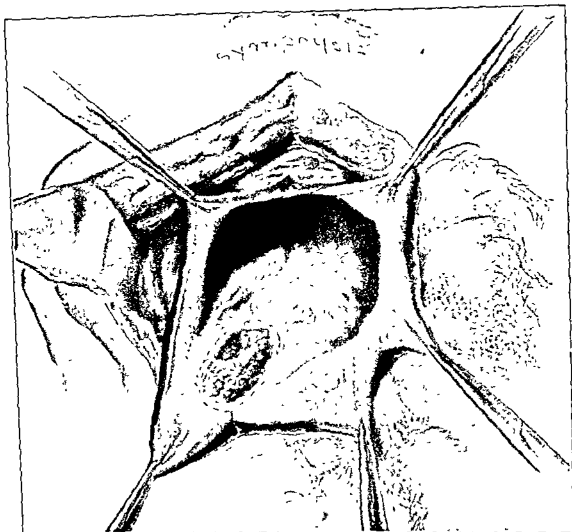


Fig. 975.—The intestines are packed off with gauze and the bladder is opened, exposing the tumor. Dotted lines indicate the line of excision with the cautery

The bladder, having been irrigated and partly distended with an antiseptic solution, is exposed by a midline suprapubic incision The loose cellular tissue between the dome of the bladder and the anterior abdominal wall is easily separated by blunt dissection up to the peritoneum. The urachus, with its accompanying vessels, is doubly clamped and divided. The upper stump is ligated and the clamp is left on the bladder attachment for traction. As the fundus of the bladder is lifted upward, the peritoneum is carefully stripped from the bladder. If the tumor involves the peritoneal surface, the peritoneum should be incised around the diseased area and the peritoneal cavity closed. If the peritoneal involvement is extensive, it is less difficult to isolate the abdominal cavity with gauze sheets and close the peritoneum after the bladder has been removed. When the bladder has been freed from

its peritoneal attachment, it is pulled upward and by traction first to one side and then to the other, and, as an assistant retracts the abdominal wound, the lateral surfaces are exposed and freed by scissors and blunt dissection. In dissecting the lateral areas several dense bands of tissue containing the vesical arteries will be encountered These should be ligated and divided.

As the base of the bladder is approached, the two vasa are exposed as they cross the ureters. They should be doubly ligated and divided. The ureters are then identified and liberated as they enter the bladder. If they have previously been divided for transplantation, the stumps are liberated and removed with the bladder.

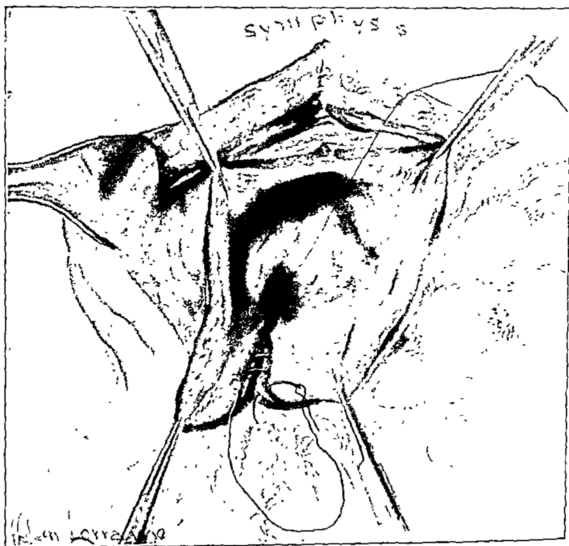


*Fig 976—After resection of the bladder, the inner row of sutures is placed, catching as little as possible of the mucosa*

If they are to be disposed of after the bladder is removed, they should be separated throughout their pelvic course, doubly ligated and divided near the bladder, with a ligature left long on the proximal stumps for identification. The bladder is now completely emptied and, as it is pulled upward, the base with the attached seminal vesicles is stripped from the rectum with the finger This dissection is continued downward, separating the rectum from the posterior surface of the prostate The bladder is then drawn backward and bands of tissue connecting the prostate to the symphysis are divided with scissors. The prostate can then be separated laterally by

blunt dissection, leaving the bladder attached only by the apex of the prostate. The prostate should be transfixed as near its apex as possible with a heavy catgut suture and divided transversely with a knife or high frequency electrode. Bleeding in the region of the prostate, which may be quite profuse because of injury to the venous plexus, is easily controlled by suturing the bleeding areas with No. 1 plain catgut. Bleeding from the stump of the prostate may be controlled in the same manner.

If, after the bladder is liberated, the prostatic area is difficult to approach from above or if the entire prostate is to be removed, the dissection is discontinued after the base of the bladder has been freed from the rectum. The patient is then placed in the lithotomy position, and the prostate and the sphincter area of the bladder are liberated as in perineal prostatectomy for carcinoma.

This operation may be done in two stages. The bladder may be freed from above and the suprapubic wound partly closed with drainage to the bottom of the wound. After a few days the prostate and bladder neck are liberated perineally and the wound is closed with drainage. The suprapubic wound is reopened and the bladder and drains are removed. Fresh drains are inserted and the abdominal wound is closed with interrupted sutures. In this case the ureters should be transplanted either to the surface of the abdomen or to the sigmoid at the first operation.

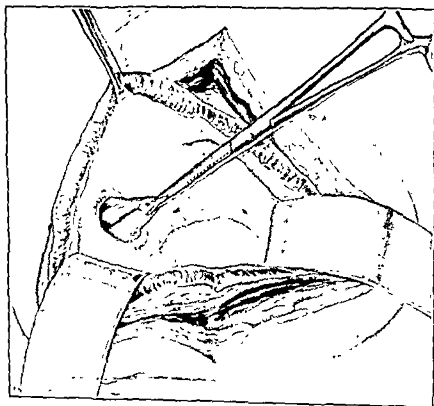


Fig 977.—The bladder is being held open by large ribbon retractors. The wall of the diverticulum is grasped with a hemostat or *tenaculum* and gradually pulled into the bladder.

## Diverticula

Diverticula of the bladder are recognized clinically in association with obstruction at the bladder orifice, or in the urethra. Frequently small nonadherent diverticula subside and at times disappear when the obstruction is removed. Excision is

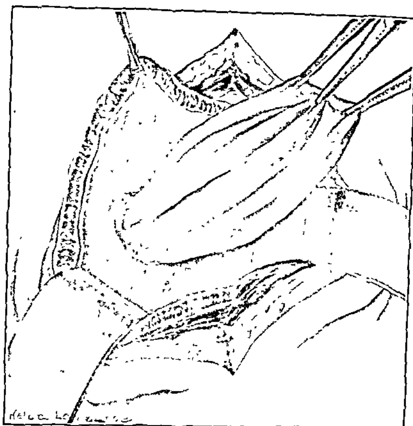


Fig 978 —The diverticulum has been completely inverted The dotted line indicates the incision for its removal

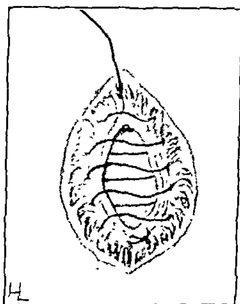


Fig 979

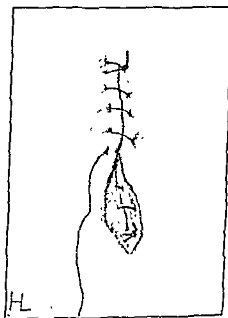


Fig 980

Fig. 979 —After the diverticulum has been excised, the wound is closed by two layers of sutures The first, of No 1 chromic catgut, includes the muscle and fibrous layers of the bladder wall

Fig 980 —The second layer of sutures, of 00 chromic catgut, closing the mucous membrane of the bladder

required when they are large or adherent to the neighboring structures. In all cases the obstruction should be removed either before or at the time the diverticulum is treated.

The diverticulum should be accurately located by cystogram and by cystoscopic examination before an operation is attempted. The bladder is opened suprapubically and the diverticulum is explored with the finger and by inspection with the patient in the Trendelenburg position. The pouch may be excised externally or it may be removed from within the bladder by the method of Young. In this operation the pouch is drawn into the bladder by a large glass tube attached to a suction apparatus. The glass tube is inserted through the neck of the diverticulum and gradually withdrawn as the wall of the pouch is sucked up into the tube. Or the wall of the diverticulum may be caught with forceps and gradually pulled into the bladder (Fig. 977). When eversion is complete, an incision is carried around the neck of the pouch through the mucosa and submucosa, and into the fibrous layer, taking care to avoid the ureter (Fig. 978). If the ureter opens into the diverticulum, a V-shaped flap is made around its orifice. The closure will leave the ureter opening into the bladder in a normal manner. After the incision has been completed around the neck of the diverticulum, the mucosa, submucosa, and a portion of the fibrous coat are dissected off chiefly with dry gauze, but using a knife or scissors to cut bands of adhesions when necessary All bleeding points are carefully clamped and ligated. When the dissection is complete, the tissue that has not been removed is returned through the diverticular opening. The cavity from which the diverticulum has been removed is explored with the finger to be sure the peritoneum has not been opened. A cigarette drain is carried from the prevesical space into the cavity left by the diverticulum, and the defect in the bladder wall is repaired by continuous sutures of chromic catgut (Figs. 979 and 980).

When the diverticulum is large or when it is adherent, it is more satisfactory to dissect it externally. After opening the bladder widely through the prevesical space and protecting the prevesical space with gauze packing, the diverticulum is explored with the finger. It may be packed with gauze to identify it, or, with one or two fingers in the diverticulum, dissection is carried through the prevesical tissues to the sac, which is lifted up by the fingers within it. If the sac is covered by peritoneum, the peritoneum may be opened, though usually this is not necessary. The vas deferens and the ureter must be identified, and injury to these structures avoided. Occasionally the ureter is involved in the diverticulum, and it may be necessary to divide it and reimplant it into the bladder. When the sac has been completely freed, the internal relation of the neck of the sac to the ureter is noted and the diverticulum is then cut away. The opening in the bladder is closed as after operations for tumors. The suprapubic opening is sutured except for a drainage tube, which comes out at the upper part of the bladder wound near the peritoneal fold. A cigarette drain is carried down through the prevesical space to the site of the old diverticulum.

### Vesical Fistula

The operative treatment of fistulas of the bladder varies with the location of the fistula and with the other structures that are involved.

Suprapubic or vesicocutaneous fistulas persist because of infection, malignant disease, or obstruction. Stones frequently accompany obstruction of the bladder,

and when they are removed and the obstruction is left untreated, a fistula may persist; likewise, a fistula will not heal in the presence of fibrosis about the bladder orifice or stricture following prostatectomy. Tuberculosis of the bladder, severe cystitis, particularly when the urine is alkaline, and carcinoma will prevent healing of the suprapubic wounds. Fistulas accompanied by obstruction will usually heal after removal of the obstruction, which in most cases can be done by transurethral resection of the obstructing tissue or by dilation of the stricture. A catheter is then tied in the urethra for drainage, and the fistula is thoroughly curetted. The bladder should be kept clean by frequent irrigations under low pressure, and the catheter should be changed twice a week. Healing is usually complete in about two weeks

Operative treatment even for the relief of obstruction should be withheld until the bladder is as free as possible from infection. Infection will frequently respond very rapidly to continuous irrigation, which may be carried out through a small catheter in the fistula with a catheter in the urethra for drainage. If the urine is alkaline, the patient should be given an acid ash diet and acidifying drugs and the bladder should be irrigated with ½ per cent phosphoric or hydrochloric acid. Ulcers will heal more rapidly if lightly fulgurated. This may be done through the cystoscope. When the bladder has healed, the fistula will very probably close if there is no obstruction.

When these measures fail, the fistulous tract should be dissected out and the bladder carefully sutured. An incision is made, the center of which encircles the fistula. The fistulous tract is dissected to the bladder, and the scar tissue is carefully removed from the fascia and muscles of the abdominal wall. The peritoneum is usually drawn down and is often adherent to the scar tissue. It is therefore wise first to expose the bladder below and on the sides of the fistulous tract and to dissect very closely to the fistula above. If the peritoneum is opened, the margins of the peritoneal wound should be liberated from the adherent scar tissue and the peritoneum immediately closed with a continuous suture of fine plain catgut. When the bladder is reached, the fistulous tract together with all scar tissue is excised. The bladder is carefully examined, and if any obstruction has been overlooked, it is removed. If there is no intravesical bleeding, the bladder should be closed in two layers of continuous sutures, using chromic catgut. A rubber drain is carried down to the bladder and brought out near the lower angle of the wound. The abdominal wound is closed by interrupted sutures of coarse silk. Urethral drainage is provided by an indwelling catheter. If, because of enucleation of prostatic tissue or the excision of fibrous tissue at the bladder orifice in relieving obstruction, intravesical hemorrhage should occur, the cavity should be packed with gauze and the bladder drained suprapubically.

If the fistula results from malignancy of the bladder, x-ray or radium with catheter drainage is the best treatment.

An enterovesical fistula occasionally results from diverticulitis of the sigmoid When an infected area of the sigmoid becomes adherent to the bladder, an abscess is formed which may rupture into the bladder. The infected loop of bowel should be separated from the bladder and resected with end-to-end anastomosis; or, if it is not too extensive, the infected area may be excised and the intestine closed The diseased area of the bladder should then be excised and the wound closed with two layers of chromic catgut sutures, one including the muscles of the bladder and the

other closing the peritoneal surface. The bladder should be drained suprapubically. When enterovesical fistulas are caused by tuberculosis or carcinoma, the disease is usually too far advanced and the patient too much debilitated to justify operation.

Vesicovaginal fistulas rarely heal without surgical treatment. The time of election for repairing the defect is six or eight weeks after the occurrence of the fistula. By this time all devitalized tissue has disappeared and the structures are not distorted by contracting scars.

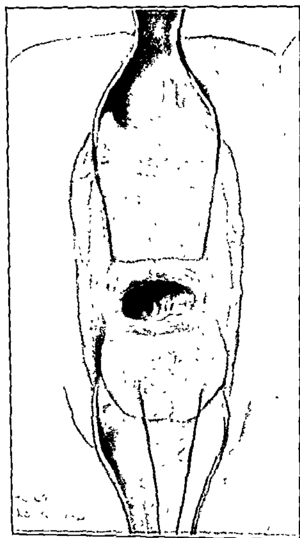


Fig 981

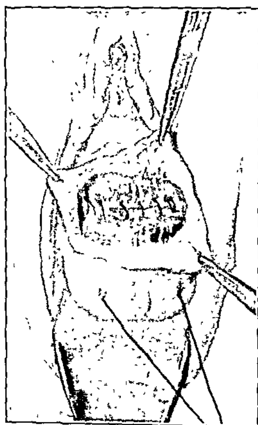


Fig. 982.

Fig 981.—Large vesicovaginal fistula The vagina is widely retracted and the cervix is pulled down by the heavy traction suture which gives good exposure

Fig. 982.—The vaginal wall has been separated from the bladder, sufficiently freed to permit easy approximation of the opening in the bladder The first row of fine kangaroo tendon sutures has been taken, turning the margins of the bladder wound inward.

Preoperative preparation is essential. If there is infection of the bladder or vagina, union of the tissues cannot be obtained. Frequently the urine is infected and the tissues of the vagina and vulva are eroded and encrusted. The urine should be made acid if necessary and the bladder and vagina frequently irrigated with warm boric acid solution Crusts should be removed and 5 per cent silver nitrate solution applied to eroded or ulcerated areas three times a week until the tissues are in a healthy condition.

Vesicovaginal fistulas are usually approached through the vagina with th tient in the lithotomy position. Adequate exposure is important, and if the va orifice is narrow, accessibility is secured by one or two posterolateral vaginal sions. By placing a large retractor in the vagina posteriorly and pulling the c downward and backward by a tenaculum or by a heavy suture passed through lips of the cervix, the fistula can usually be brought into view (Fig. 981). If th tula is small and its margins are readily opposed without tension, it may be c with interrupted sutures of silver wire or silkworm-gut. The mucous membra trimmed from the vaginal wall for a depth of about half a centimeter around th tula, and scar tissue is removed until a healthy bleeding surface remains. The gins of the mucous membrane of the bladder need not be disturbed. After c mining the direction in which closure will produce the least tension, interrupte tures are placed. A tenaculum may be used to steady the margins of the wo



Fig 983.

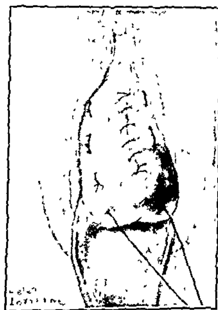


Fig 984.

Fig 983 —A second row of fine kangaroo tendon sutures has been placed in the bla wall covering the first layer. In the lower angle of the vaginal wound the first of the i rupted sutures of kangaroo tendon has been placed.

Fig. 984 —The completed operation The vaginal wound has been closed with i rupted sutures of kangaroo tendon including all the layers and a continuous suture of N chromic catgut, closing the margins of the wound

The sutures, either of silkworm-gut or silver wire, are placed about 0 6 cm. ap entering on one side near the freshened border in the vagina and emerging just neath the mucosa of the bladder, then entering the other side just beneath the cous membrane of the bladder and emerging on the vagina opposite the orig point of entrance. The sutures are tied just tightly enough to approximate tissues snugly without blanching. Wound edges not approximated between the tures are closed with superficial interrupted sutures of catgut.

When scar tissue prevents approximation of the margins of the fistula with tension, and when the opening is irregular in outline or larger than one centim in diameter, we prefer to dissect the bladder from the vaginal wall and close wound in layers With a sharp-pointed knife and with scissors the scar tissu

trimmed from the margins of the fistula. The bladder is then dissected from the vaginal wall sufficiently to permit the margins of the fistula to be approximated without tension. Occasionally the posterior surface of the fistula must be dissected from the cervix. If the ureters open at the margins of the fistula, their orifices should be carefully turned into the bladder when the sutures are placed. Sometimes it is advisable to split a ureteral orifice back about half a centimeter. The bladder is closed in two layers. We prefer fine kangaroo tendon. The first sutures are so placed as to turn the vesical mucosa into the bladder (Fig. 982). This is buried by a second row of continuous sutures (Fig. 983). The wound in the vagina is closed in two layers; the first layer consists of interrupted mattress sutures of kangaroo tendon placed in an anteroposterior line about a centimeter apart and far enough from the margin of the wound to hold the vaginal wall up to the base of the bladder. The excess tissue is then trimmed away, and the margins of the wound are snugly approximated by a continuous suture of No. 1 chromic catgut (Fig. 984). If because of excessive scar tissue the vaginal flaps will not cover the entire bladder surface, the vagina should be lightly packed with petrolatum gauze and the wound will heal by granulation.

Absolute and constant drainage of the bladder is essential following an operation for vesicovaginal fistula. A catheter should be inserted at the time of operation and given constant attention until the wound is healed. Obstruction of the catheter for even a short time may cause the wound to break down.

When the vagina is quite small or the fistula is situated in a position difficult to approach, it is often more satisfactory to make the repair through a suprapubic incision in the bladder. The patient is placed in moderate Trendelenburg's position and the bladder is exposed through an adequate suprapubic incision. After exposing the anterior surface of the bladder, it is more satisfactory to incise the bladder transversely near the peritoneal reflection. A transverse incision is easier to suture, and prolonged fistula is less frequently encountered. The incision should be adequate for easy exposure of the interior of the bladder. With retractors placed so that the area about the fistula is slightly taut, the repair is less difficult. The tips of retractors placed in the bladder should be protected with gauze to prevent slipping and irritation of the mucous membrane. The ureteral orifices should be identified, and if very near the margin of the fistula, it is well to pass small catheters in them for identification and protection. With a small sharp-pointed knife the margin of the fistula is excised. The line of cleavage between the walls of the bladder and vagina is identified, and the bladder base is separated from the vagina in all directions until the margins of the wound come together without tension. Small hooks and delicate blunt-nosed, slightly curved scissors are useful in this dissection. The vaginal and bladder walls are then sutured separately. The vaginal wall is necessarily sutured first and may be closed with a purse-string suture or by interrupted sutures placed so that the margins of the vaginal wound will be turned downward. All bleeding should be controlled. No. 0 chromic catgut sutures may be used for this but fine kangaroo tendon is preferred. The bladder wall is closed by interrupted sutures of 0 chromic catgut so placed to include the entire thickness of the bladder wall except the mucous membrane and to invert the mucous membrane. The mucous membrane of the bladder may be lightly approximated with a continuous suture of 000 plain catgut. The success of the operation depends upon freedom from tension on the suture line and accurate approximation

of the wound margins. Following the repair, a suprapubic tube is placed in the bladder and the suprapubic wound is closed in layers. When suturing the bladder, it is well to avoid including the mucous membrane which should be turned inward. When a transverse incision is used, the suprapubic drainage tube is inserted through a stab wound just above the bladder incision.

Since it is necessary that the bladder remain entirely empty, an indwelling urethral catheter in addition to the suprapubic tube is a good precaution for the first week. The suprapubic tube may then be removed and drainage continued for another week with the catheter.

## THE URETHRA

### Urethral Caruncle

Urethral caruncles are either papillary or sessile. The papillary growths are easily removed by clamping the base with a small narrow-bladed forceps and excising the growth with the high frequency knife or a small cautery. Care must be taken to fulgurate or cauterize the base thoroughly to prevent recurrence.

The sessile growths have a broad base frequently occupying half or more of the circumference of the meatus In this type of growth we have used the following method with good results: An incision extending through the mucosa and submucosa is made to encircle the meatus at the junction of the mucous membrane of the urethra with that of the vestibule (Fig. 985). The mucosa and submucosa are dissected free to a point just behind the posterior margin of the growth. The separated mucosa is split back to the limit of the dissection at an area free from growth, and a suture is taken securing the mucous membrane of the urethra to that of the vestibule (Fig. 986). As the dissected portion of the urethra is trimmed away, the wound is closed with interrupted sutures of fine chromic catgut (Figs. 987 and 988). This prevents retraction of the urethral wound. In this way the growth is easily removed and a healthy meatus remains (Fig. 989). We have never seen a recurrence following this operation.

### Meatotomy

Meatotomy is often necessary for stenosis of the meatus and to permit instrumentation when the meatus will not admit a No. 26 French instrument. It is often advisable in the treatment of urethritis when the meatus is too small to permit adequate drainage

A cotton swab soaked in 5 per cent cocaine is inserted in the meatus for about two minutes A small amount of 1 per cent procaine solution is then injected into the lower margin of the meatus. The glans penis is held in one hand and the meatus is cut downward in the midline with a small knife. The incision should be carried deep enough for the meatus to admit a No 28 French instrument easily. The bleeding is controlled by constant pressure for about five minutes. To facilitate healing and prevent contraction, it is advisable to place a small, absorbable suture on each side approximating the mucous membrane of the urethra to that of the glans

### Internal Urethrotomy

Internal urethrotomy is used in very dense strictures of the anterior urethra which do not yield to dilatation with sounds. The stricture must be of sufficient

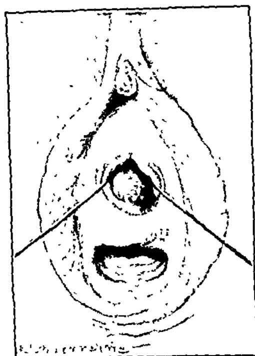


Fig. 985.

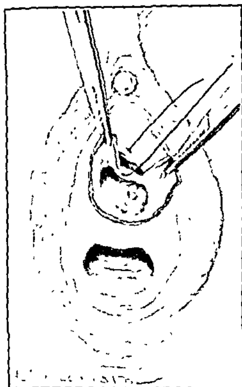


Fig. 986.

Fig. 985.—Excision of caruncle. Dotted line indicates line of incision which is carried through the submucosa.

Fig. 986.—The urethra has been dissected free to a point just behind the caruncle. The meatus has been split back to healthy tissue, and a suture is taken in the angle, fixing the urethral mucosa to that of the vestibule.

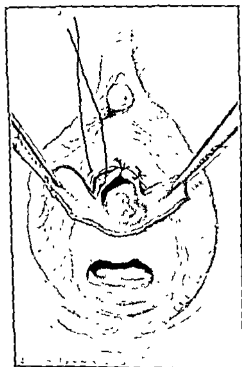


Fig 987.

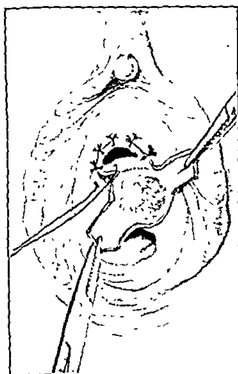


Fig 988.

Fig. 987.—As the diseased portion of the urethra is excised, interrupted sutures of 0 chromic catgut are taken to prevent retraction of the urethra

Fig 988 —The wound is closed as the growth is excised.

caliber to admit a small instrument. With the bladder partially distended with fluid and the urethra having been irrigated, a filiform is passed and screwed onto the urethrotome. The staff of the instrument is passed gently through the urethra until the tip rests in the prostatic urethra. The penis is then drawn out until the anterior urethra is under considerable tension. The obturator carrying a guarded knife is then passed along the grooved staff until the stricture is reached. When resistance indicates the presence of the stricture, the operator forces the blade through the stricture. The release of the obstruction will indicate that the stricture has been divided. The knife may then be gently passed through the remainder of the anterior urethra, dividing any other strictures that may be encountered. The knife should not be carried beyond the bulbous urethra, as incision into the membranous urethra may cause considerable bleeding. The cut should be made on the roof of the urethra and should not be repeated except in very dense strictures, when a small blade may be passed first, to be followed by a larger blade which is inserted in the same incision. The instrument is then removed, leaving the filiform in place. The filiform is screwed on a sound or dilator which is used to dilate the urethra to the desired caliber. Successive sizes may be used up to 28 or 30 French.

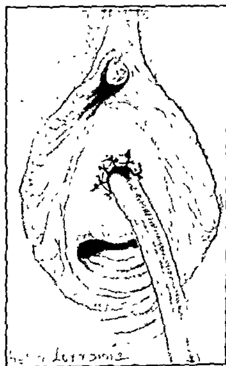


Fig 989 —The completed operation. An indwelling catheter is left for forty-eight hours

Following the dilatation a large urethral catheter should be passed and the bladder thoroughly irrigated with an antiseptic solution. If there is much bleeding, the catheter is tied in the urethra and a pressure bandage is placed around the penis. Following the operation it is necessary to pass sounds at first once a week and later at gradually increasing intervals to prevent recurrence of the stricture. Most strictures will respond to gentle dilatation without the necessity of urethrotomy.

### External Urethrotomy

External urethrotomy is done for simple drainage of the bladder when it is desirable to put the anterior urethra at rest, to prevent contamination of plastic opera-

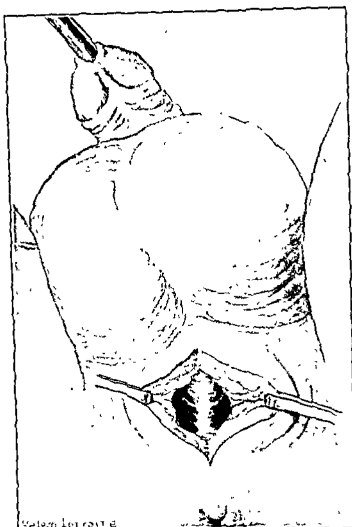


Fig. 990.—Incision for exposure of stricture in bulbous or bulbomembranous portion of urethra.

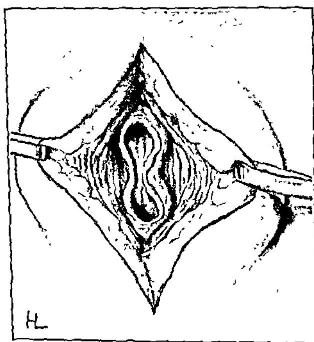


Fig 991.—The strictured area has been exposed and scar tissue dissected away.

tions on the urethra, and for the treatment of deep and impassable strictures. The urethra is opened through the perineum. The operator presses on each side of a sound passed to the stricture with the fingers and makes an incision from 2.5 to 5 cm. in length directly over the sound and in the midline of the perineum (Fig. 990). The tissues are divided to the sound (Fig. 991). Bleeding points are clamped and ligated and the mucous membrane is caught with sharp-toothed forceps or with sutures and the sound is withdrawn. The operator may then pass instruments for the dilatation or incision of the stricture or introduce a catheter for drainage. If drainage is being instituted preparatory to a plastic operation on the urethra, it is well to pass a ligature of heavy silk around the urethra just external to the urethrotomy and to tie it just tightly enough to occlude but not to cut through the urethra. By this precaution urine that may be forced around the catheter cannot pass into the anterior urethra. If the urethrotomy is done for the treatment of stricture, the mucous membrane is caught and the point of a small knife is carefully forced through the stricture, using the posterior surface of a sound or grooved staff as a guide. It is well to dissect away as much of the scar tissue as possible, taking care to preserve a strip of mucous membrane through the strictured area. A large catheter is then inserted through the meatus and into the bladder (Fig. 992). The cavernous and muscle tissues of the bulbous urethra are then drawn snugly together over the catheter by a continuous suture of plain catgut (Fig. 993). The perineal fascia is closed with catgut and the skin and superficial fascia are united with interrupted sutures of fine silk except at the lower angle of the wound, where a small drain is inserted (Fig. 994). The catheter is fastened in the urethra and retained for about ten days. Dilatation of the urethra is continued until healing is complete and a normal caliber is assured. The urethral mucous membrane covers a defect very rapidly, and extensive plastic operations for the relief of stricture are rarely indicated.

When it is impossible to introduce a sound or staff into the bladder, external urethrotomy becomes more difficult. A sound is passed down to the point of obstruction, which is usually in the bulbomembranous urethra. The incision is carefully carried down to the sound and the bleeding is controlled by clamping or by whipping over the bleeding points with fine plain catgut. The urethra is incised as far as the obstruction. Sometimes a view of the stricture can be obtained and a probe or bougie accurately introduced through the stricture. If a sharp-pointed hemostat can be introduced, the jaws are spread apart and the stricture is dilated. A pair of larger forceps is then inserted and the jaws are spread. When the stricture is very dense or when there is a considerable amount of inflammation, it may be divided by an incision with a knife.

If the opening in the stricture cannot be inspected, a filiform bougie may be introduced through the urethral wound. This will serve as a guide for the introduction of a larger instrument, or a pair of sharp nose forceps, or a knife to divide the stricture. The stricture is thoroughly divided, the scar tissue dissected away, and a catheter is inserted. The wound is closed as previously described.

If the opening in the stricture cannot be located, prolonged blind dissection is unwarranted and may cause considerable damage to the perineal structures. It is preferable to locate the urethra by retrograde passage of sounds either suprapubically or through the perineum. If the suprapubic route is chosen, the bladder is

tomy. When the apex of the prostate is reached, a small incision is made in the proximal end of the membranous urethra, and a catheter or sound is inserted and passed back to the stricture. Frequently a filiform, when thus introduced, will pass through the stricture.

When strictures are accompanied by acute inflammation, we have frequently drained the bladder by a suprapubic or a perineal incision without disturbing the stricture. When the inflammation has subsided, filiforms and sounds can usually be passed without difficulty.

Occasionally after a rupture of the urethra it is impossible to enter the bladder from below. Here a small suprapubic incision is made and the urethra is catheterized or a sound is introduced into the urethra from within the bladder. This will demonstrate the location of the urethra in the perineal wound and is a much safer procedure than a prolonged blind dissection in the perineum.

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# CHAPTER 72
# THE PROSTATE GLAND

Austin I. Dodson

## PATHOLOGY

Obstructive lesions of the prostate gland present many interesting pathologic variations. It is therefore obvious that no single method of treatment can be expected to correct widely varying types of lesions and in all cases alike restore the urinary tract to normal function. The crippling effects of the obstruction on the upper urinary tract and on the circulatory system, together with the many complications that may attend advancing years, likewise require variations in the treatment administered.

Although it is proposed here to discuss the surgical management of prostatic obstruction, the subject will be clarified if the discussion is prefaced by a brief outline of the pathologic and clinical problems encountered. The three major pathologic lesions in the prostate are carcinoma, median bar, and glandular hypertrophy. The treatment of carcinoma consists of radical excision if the disease is recognized while still confined to the prostate. When it has spread to surrounding tissues, the purpose of treatment is to afford bladder drainage, to retard the growth and metastasis of the cancer, and to keep the patient as comfortable as possible. The administration of stilbestrol, castration, or both, will usually cause a period of regression of the process and retard metastasis. When obstruction is not relieved by this treatment, transurethral resection should be done to restore bladder function.

Median bars are caused by fibrous tissue contraction resulting from long-continued inflammation of the prostate involving the bladder orifice. The tissues about the internal sphincter become somewhat fixed, with stenosis and a lack of elasticity of the internal sphincter. The patient is usually younger and in better physical condition than the patient suffering from glandular hypertrophy, but the symptoms and pathologic changes in the bladder and kidneys are similar. In my experience, diverticula of the bladder have occurred more frequently with median bars than with glandular hypertrophy. This seems logical since the formation of the bar is a slower process than the growth of glandular hypertrophy. True glandular hypertrophy consists of a proliferation of glandular tissue in, or adjacent to, one or more of the lobes of the prostate. The most frequent hypertrophies arise from the lateral lobes and the posterior commissure or median lobe. When hypertrophy is confined to the lateral lobes, the enlargement remains below the internal sphincter. The urethra is encroached upon laterally and its anteroposterior dimension is greatly increased. The internal sphincter is not dilated. This is the class of patients who may present very large glands on rectal palpation with very little residual urine. They are subject to attacks of complete retention, which may subside after catheterization or a few days

of bladder drainage, leaving the bladder function clinically almost normal until a similar attack returns. These patients, often encouraged by such experiences, delay operation until their general health is greatly impaired. Such cases may also give a false sense of value to nonsurgical measures, such as hormonal therapy, in the treatment of prostatic hypertrophy.

Posterior commissural hypertrophy presents itself as a mass of glandular tissue bulging from the posterior area of the internal sphincter. The sphincter is dilated and often assumes a crescent appearance. The trigone is hypertrophied as a result of interference by this glandular mass with its normal function. When lateral lobe enlargement accompanies hypertrophy of the posterior commissure, the hypertrophied tissues protrude through the dilated sphincter, often producing very large masses in the bladder. When the bladder musculature can no longer overcome the obstruction, residual urine slowly but constantly increases, the bladder wall then becomes thinned, and frequently pronounced impairment of the kidneys occurs before the patient realizes his need for medical attention. Once complete retention has occurred, normal voiding is not reestablished except by the removal of the obstructing tissue. The subcervical glands of Albarran, situated beneath the trigonal mucosa at the sphincter, may hypertrophy producing another type of middle lobe. The mass of tissue is somewhat more rounded than posterior commissural hypertrophy and is often almost pedunculated. Growing above the muscle it does not cause hypertrophy of the trigone. It does, however, produce a most effective barrier to normal voiding. The growth causes dilation of the sphincter and, when accompanied by lateral lobe hypertrophy, it produces a pathologic and clinical picture similar to the combined enlargement of the lateral lobes and of the glands of the posterior commissure. Significant enlargement of the anterior commissural glands is unusual and never occurs except in unison with hypertrophy of other areas. Since the advent of transurethral resection, failure to restore bladder function has resulted from overlooked masses of tissue in this area The posterior lobe of the prostate is often the site of carcinoma but is rarely involved in benign hypertrophy.

## CLINICAL COURSE IN PROSTATIC OBSTRUCTION

In addition to pathologic variations, the clinical course of the prostatic patient is influenced by a number of factors, including infection, calculi, and circulatory disturbances, as well as unrelated constitutional diseases. These factors influence both the course of the disease and the method of treatment. The choice of treatment, therefore, must be determined after careful study, not only of the nature of the pathology and of the clinical manifestations, but of unrelated diseases and frequently of the social and economic problems as well

In the advanced stages of obstruction there is always some impairment of the kidneys and often of the circulatory system. Reestablishment of drainage preliminary to operation improves the function of these organs and permits prostatectomy to be done with relative safety. The type of drainage to be instituted must be decided for each case. An indwelling catheter is the method of choice if the patient can tolerate it Many patients suffer so much from the presence of the catheter that it is necessary to institute drainage by suprapubic cystotomy. When this is done, a soft mushroom catheter is introduced and the bladder is sutured watertight around it, thereby making the patient much more comfortable

The trocar is frequently used to establish suprapubic drainage in greatly debilitated patients when the bladder can be palpated above the pubis. There is little danger of peritoneal injury and it causes much less shock than cystotomy. When drainage must be continued over a period of weeks, it is safer than catheter drainage because of the relative freedom from infection.

The length of time required to determine when patients can stand prostatectomy differs in every case. Those coming early with very little residual urine and all of their organs functioning normally may be operated upon after a few days' preliminary care, while others may require weeks or months. It is interesting to note that constant drainage of a bladder long accustomed to retention seems to have as much beneficial influence on the crippled heart and vascular circulation in some cases as it does on the damaged kidneys. There is always a marked fall in blood pressure following the relief of long-continued retention of urine, and this seems to be a considerable factor in the suppression of urine following the too rapid emptying of a distended bladder. All chronically distended bladders should be emptied gradually. We have noted a fall of 35 points in the systolic pressure following the institution of drainage when the residual was only 250 c.c.

In some cases following the institution of drainage the patient's kidney function, blood pressure, and sense of well-being decline together for the first few days, and during this time the patient should be closely watched. A full intake of fluids is required and active supportive measures are instituted if necessary. Diuretics have not proved of value in our hands, and hot packs are too depressing for the average old man Uremic symptoms can usually be controlled by a large intake of fluids, free elimination of the bowels, and cardiac support.

Following the institution of drainage, the blood pressure is taken daily and the kidney function checked up once or twice a week, according to the patient's general condition. The phenolsulfonphthalein test, the blood urea nitrogen estimation, and the specific gravity and total volume of the urine are the guides to the kidney function. These tests often show marked fluctuation during the first few days following drainage. When the kidneys become adjusted to normal conditions and begin to improve in function, the tests taken at different times become more constant, indicating that the kidneys have reached their normal function. The blood pressure also fluctuates following the institution of drainage, and a constant blood pressure should be maintained at least three days before prostatectomy is done. Every patient with any cardiac weakness should be thoroughly studied by an internist and appropriate treatment instituted.

The choice of an anesthetic enjoys a prominent place in the literature on this subject. In most cases spinal anesthesia is quite satisfactory and for prostatectomy not more than 100 mg. of procaine is needed. If the patient is given ¾ grain of ephedrine immediately before the anesthetic, very little fall in blood pressure will result from so small a dose. Safety is increased by giving 5 per cent dextrose in Ringer's solution intravenously during the operation. The rate of flow is regulated by the blood pressure When spinal anesthesia is contraindicated, ethylene-oxygen is an ideal anesthetic for these patients. It gives sufficient relaxation for operation by either route, does not seem to retard the function of any organ, and is peculiarly free from the nausea and flatulence so distressing to these old men after other general anesthetics.

Just before the patient is taken to the operating room his urethra and bladder are thoroughly irrigated with boric acid solution. As soon as the patient is under the anesthetic, hypodermoclysis of Ringer's solution is started or 5 per cent solution of dextrose in Ringer's solution or water is given slowly by vein. In this way a large amount of fluid is given without discomfort to the patient and when most needed.

## POSTOPERATIVE TREATMENT

When the operation is over, the patient is returned to a warm room and kept absolutely quiet. Sufficient morphine is administered to relieve all discomfort. The pulse is closely watched, and frequent blood pressure readings are taken. In the event of excessive bleeding the packing is reinforced. An adequate fluid balance is maintained and shock is usually avoided by the administration of 5 per cent dextrose in water, saline solution, or Ringer's solution, as needed. Fully 95 per cent of all prostatic fatalities are due to shock, hemorrhage, uremia, and sepsis. A persistently low blood pressure from shock or anemia from hemorrhage, in addition to its immediate danger, predisposes the patient to uremia and sepsis. Hemorrhage is a predisposing factor in shock, and blood transfusion is of inestimable value in the treatment of both hemorrhage and shock. In several cases we believe it saved the life of the patient. In others it has insured a smoother convalescence.

At the end of twenty-four hours after operation the packing, if used, is removed under Pentothal Sodium anesthesia, and any loose sutures are tied. This is done in the patient's room. Thorough drainage is assured either through a suprapubic tube or an indwelling catheter. The bladder is irrigated daily with warm boric acid or potassium permanganate solution. The patient is thereby kept more comfortable and the danger of sepsis is minimized.

Uremic symptoms following prostatectomy in properly prepared patients are usually due to an ascending infection from the bladder brought on by disintegrating blood clots or incomplete drainage. The attack is ushered in by a chill followed by high temperature, a diminished urinary output, and sometimes with delirium or coma. The patient usually responds promptly to forced fluids, the administration of antibiotics, and irrigations of the bladder.

For the prevention of pulmonary complications, the patient's position in bed should be changed frequently and he should sit up in bed as soon as possible. To insist that he get out of bed in three or four days, especially against his will, is not consistent with the best interests of the patient.

A stable kidney function and circulatory system before prostatectomy, and the selection of the proper operative route to fit the prostate, are extremely important. The transfusion of blood in the treatment of shock and hemorrhage, and forced fluids, free drainage, and the continuation of cardiac stimulation, when necessary, are valuable measures in the therapy of these patients.

## CHOICE OF TREATMENT

If carcinoma is recognized or strongly suspected while still confined to the prostate, Young's radical perineal operation, consisting of removal of the entire prostate along with the seminal vesicles and a cuff of the bladder, offers a chance of cure. When the diagnosis is uncertain, a biopsy should be obtained upon exposure of the

prostate, and a less radical operation is done if cancer is not present. This operation is not generally employed, chiefly because of the difficulty in its execution and the danger of incontinence. It is, however, the only method of treatment by which the cure of prostatic cancer is possible.

In the more advanced cases the purpose of treatment is to afford bladder drainage, to retard growth and metastasis of the cancer, and to keep the patient as comfortable as possible by the use of estrogens, castration, and transurethral resection. Permanent suprapubic drainage should be used only in those patients too feeble to permit more radical treatment or when all other methods of restoring bladder function have failed.

In obstruction by median bars bladder function is restored by the excision of small amounts of fibrous tissue from the posterior portion of the internal sphincter area. This condition is suspected when the patient is presenting the symptoms of prostatic hypertrophy and has no palpable enlargement of the gland. The patient is usually younger by ten or fifteen years than the average patient with benign hypertrophy, although occasionally bars are seen in the very aged. The condition is determined by cystoscopic study. Young was the first to recognize that prostatectomy was unnecessarily extensive in these cases and devised his "punch," which is quite satisfactory in removing sufficient tissue to restore bladder function. At the present time Young's instrument is not so widely used as a number of modifications which are equipped with more adequate visual systems. The McCarthy resectoscope and the Day punch may be used with equal satisfaction in treating these cases. When the bar is complicated by nodules of prostatic tissue, the resectoscope is more satisfactory. Keyes devised a rongeur for excising these bars suprapubically, which is useful when the bar is complicated by a stone or a diverticulum that necessitates the opening of the bladder. In such cases the bar may also be excised by a high frequency loop electrode.

In the treatment of benign hypertrophy of the prostate it is the purpose of the surgeon to restore the bladder to normal function. When this is accomplished, urinary drainage is assured and the kidneys and circulatory system are relieved of the devastating influence of back pressure. Nonsurgical measures are useful in the very early stage of hypertrophy, in the preparation of patients for prostatectomy, and when the operation must be deferred because of physical or economic reasons. Patients who are seen in the early stages of hypertrophy do not always require surgical treatment; in fact, the advisability of operating upon all early cases is questionable. When the kidney function is good, the residual urine not more than an ounce and free of infection, the patient may be permitted to delay treatment, with the advice that he report at intervals of six months for examination. Urinary frequency in the early stages results from congestion or infection and is usually relieved by prostatic massage, gentle gravity irrigations, and urinary antiseptics. Similar treatment is helpful in more advanced cases when, because of feeble health or business or financial reasons, operation must be deferred. In no instance, however, should the surgeon suggest the probability of complete and permanent relief by any other means than enucleation or excision of the hypertrophied prostatic tissue. Hypertrophy of the prostate is a slow, but continuous process, and although it may be delayed by palliative measures, the enlargement, if not removed, continues until complete obstruction has occurred

The location and size of the hypertrophy, the degree of kidney damage, and the age and physical condition of the patient should be carefully considered when choosing an operative procedure for the relief of prostatic hypertrophy. Transurethral resection or excision of hypertrophied tissue has now been used sufficiently long for its usefulness to be accurately evaluated. While a few expert and enthusiastic urological surgeons prefer to treat all cases in this manner except those in which, for some reason, the instrument cannot be passed into the bladder, the majority take a more conservative view and apply it chiefly to those obstructive lesions at the vesicle orifice and to moderate hypertrophy of the lateral lobes. When there is advanced hypertrophy of the lateral lobes alone or combined with hypertrophy of the posterior commissure or Albarran's gland, most operators prefer to enucleate the gland. The surgeon whose experience with the resectoscope is limited will do well to limit his resections to the smaller hypertrophies. Patients with badly infected glands who respond to instrumentation with chills and fever will do better with suprapubic drainage and enucleation of the gland. This is likewise true of the occasional patient whose gland is very vascular and bleeds freely upon the most gentle instrumentation. In aged and feeble patients suprapubic prostatectomy is attended by a higher mortality than either transurethral resection or perineal prostatectomy. The experience of the operator should influence the procedure.

The choice between perineal and suprapubic prostatectomy has been a controversial subject since the beginning of prostatic surgery. The relative simplicity of suprapubic prostatectomy has made it the choice of a majority of surgeons and especially those who do prostatectomy only occasionally. Perineal prostatectomy, although more difficult of execution, insures a higher percentage of recovery and in the hands of the experienced operator gives equally good functional results; furthermore, the surgeon who is familiar with the perineal approach is better equipped to deal with the various pathologic processes that may occur in the posterior urethra, prostate, and seminal vesicles.

Most surgeons prefer to do suprapubic prostatectomy in two stages A suprapubic cystotomy is done, at which time the bladder may be explored and stones if present removed If there is a diverticulum it should be removed at this time if the patient's condition justifies the added risk. After a period of drainage sufficient to restore the patient's kidney function to a safe level and when his general physical condition will justify it, the bladder is reopened and the prostate is removed. In extremely debilitated or uremic patients a period of drainage by a catheter in the urethra or by a tube placed suprapubically through a trocar adds to the safety of the first stage. Suprapubic cystotomy alone, done routinely and immediately upon admission, is responsible for a considerable mortality. When the patient enters the hospital in good physical condition with little or no impairment of the kidney function, suprapubic prostatectomy may be done safely at one operation with considerable saving in time and discomfort to the patient

## TRANSURETHRAL RESECTION

Transurethral resection consists of the removal of the obstructing tissue in small portions by an instrument introduced through the urethra Several instruments have been devised for this work. The most popular one is the Stern-McCarthy pros-

tatic electrotome with the McCarthy visual system. The instrument is used in conjunction with a high frequency current of sufficient intensity to cut under water.

Some operators prefer an instrument patterned after the Young punch, but equipped with a more efficient visual system and with means for continuous irrigation. The Day punch and the Braash punch as modified by Bumpus and by Thompson are popular instruments of this type.

The operation is highly technical. Its use should be limited to those thoroughly familiar with cystourethroscopic instruments and procedures. Though the operation may be done in all forms of prostatic obstruction, except the rare enormous enlargements, it is most useful in the correction of median bars, small and moderate middle lobes, and mild general prostatic hypertrophy. Resection is contraindicated in very large prostates, in those which bleed freely upon the slightest instrumentation, in those in which there is marked distortion of the course of the urethra, and in those in which the indwelling catheter incites persistent fever.

The preoperative preparation of a patient for transurethral resection does not differ from that in which an enucleation of the prostate is to be done. In robust patients with little residual urine and good kidney function, very little preparation is necessary. Those whose kidneys and circulation have been impaired by prolonged retention of urine require preliminary drainage and supportive treatment until the operation can be done reasonably safely. In all cases, preliminary x-ray examination of the urinary tract and cystogram are desirable. By such means the type of obstruction is determined and complications such as stones and diverticula are located or excluded. The patient who has chills or runs a temperature following instrumentation is not a good risk for transurethral resection. Preliminary drainage in these cases is usually accomplished by an indwelling catheter. The bladder should be irrigated from one to several times a day depending upon the character of the urine, and the catheter should be changed and the urethra thoroughly irrigated at least twice a week. The patient should be free of fever at least two days before the transurethral resection is done.

It is our custom to keep the urine highly acid by the administration of ammonium chloride when necessary during the period of drainage and to give large doses of antibiotics twenty-four hours before instrumentation or resection.

The operation is usually done with spinal or sacral anesthesia When spinal is used, from 50 to 100 mg. of procaine will give adequate anesthesia

The bladder is thoroughly irrigated and the catheter is removed. The urethra is then irrigated and the sheath of the resectoscope is introduced. The working parts of the instrument are then fitted into the sheath and attached to an irrigator, to a battery for light, and to a high frequency generator for cutting current. The bladder and posterior urethra are first carefully inspected. The verumontanum is located This landmark is important, because to cut distal to it endangers the patient's urinary control (Fig. 995). Excision is usually begun upon the most obstructive portion of the gland, such as a median bar, median lobe, or posterior commissure hypertrophy. The resection is continued posteriorly until all of the obstructing tissue is removed and there is a clear view from the verumontanum to the bladder (Fig. 996).

If the lateral lobes of the gland bulge into the urethra, they should then be removed, first one and then the other (Fig. 997). It is much more satisfactory to complete the resection as far as possible in one area before going to another, as this

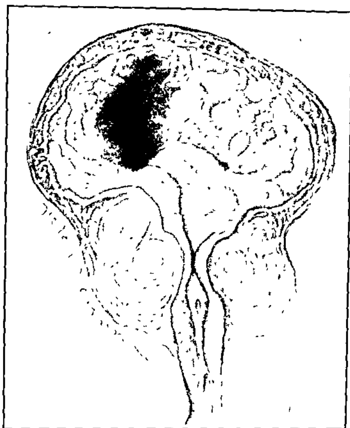


Fig. 995 —Hypertrophy of the prostate suitable for transurethral resection There is generalized hypertrophy, but the gland is not extremely large.

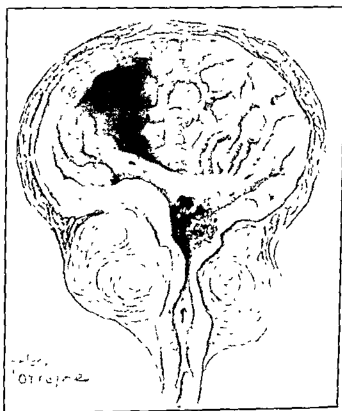


Fig 996 —The median lobe has been removed.

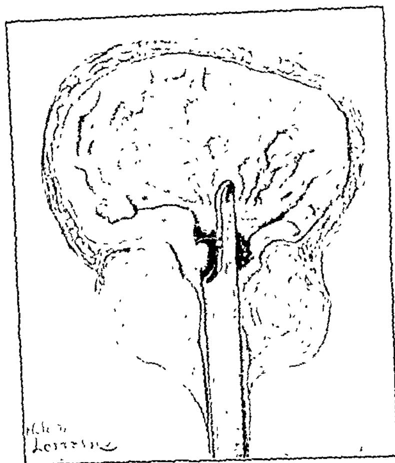


Fig 997 —The loop of the resectoscope engages the right lateral lobe.

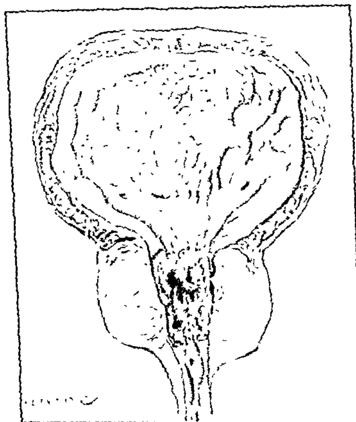


Fig. 998 —The completed operation. All obstructing tissue has been removed, leaving a funnel-shaped channel from the verumontanum to the bladder. To cut anterior to the verumontanum endangers bladder control.

makes it easier to control the bleeding and to keep one's anatomical bearings Before cutting in a new area, all bleeding points should be carefully controlled by fulguration. When all obstructing prostatic tissue is removed, and no tags or nodules of tissue can be seen bulging into the bladder or urethra (Fig. 998), and when the bleeding has been stopped, the resectoscope is removed and a large catheter No. 22 or 24 French, preferably with two eyes, is inserted and tied in the urethra. If bleeding is difficult to control, a Foley bag or similar instrument may be inserted. The bag is inflated and traction is made on the catheter, thus adequately controlling the bleeding by pressure. I prefer to use these bags only in those cases in which the control of bleeding by fulguration would prolong the operation beyond the point of safety. Infection is encouraged by their presence The patient is returned to his room, given fluids freely by mouth if possible, by hypodermoclysis or intravenously if necessary, and the catheter is watched carefully for bleeding and irrigated sufficiently often to prevent occlusion with clots. The urine is usually blood tinged for twelve to twenty-four hours, but if hemostasis is carefully carried out at operation, no trouble is experienced. If bleeding is sufficiently profuse to form clots in the bladder, the patient should be returned to the operating room, the clots removed, and the bleeding points fulgurated. Occasionally a patient bleeds so profusely during the operation or afterward that control through the urethroscope is impossible. In such cases one should not hesitate to open the bladder suprapubically and pack the prostatic cavity.

Catheter drainage is usually necessary for about a week following the operation. We prefer to leave the catheter in until the fever has subsided. Occasionally a degree or two of fever persists until the catheter is removed. Following removal of the catheter, the patient should be catheterized and the bladder irrigated every twelve hours, until the patient is able to empty the bladder completely. The retention of infected urine following a resection is quite dangerous, often causing chills and fever.

The principal complications that may occur during this operation are hemorrhage, rupture of the bladder, and injury to the bladder. Excessive hemorrhage is rare if one is careful to control the bleeding following each cut that is made, and to stop all bleeding in one area before turning to another. Rupture of the bladder is rare and results from overdistention. If rupture occurs, the patient complains of severe abdominal pain and muscle rigidity. Immediate suprapubic exposure and repair of the injury should be done and suprapubic drainage established. Injury of the bladder with the resectoscope usually results from cutting too far into the bladder, or cutting through and undermining the trigone. This accident is recognized by difficulty in reintroducing the instrument into the bladder when it has been withdrawn into the urethra, by failure of the irrigating fluid to return satisfactorily, and by suprapubic pain and shock. It is preferable in such a case to institute immediate suprapubic drainage

The chief postoperative complications are hemorrhage and sepsis. Hemorrhage may occur immediately because of inefficient control at operation, or a week to ten days following operation resulting from slough. The prevention of primary bleeding has been discussed. Secondary hemorrhage is less apt to occur when fulguration has not been excessive and when the urethra and bladder have been kept clean by frequent irrigations. The aspiration of clots, thorough irrigation with warm anti-

septic solution, and putting the bladder at rest by an indwelling catheter will frequently control secondary bleeding; if not, the resectoscope should be introduced and the bleeding points fulgurated.

We have previously mentioned the importance of delaying operation until the temperature remains normal for at least two days, and the value of acidifying the urine and administering antibiotics before operation. Patients who persistently have fever following instrumentation or the application of an indwelling catheter are poor subjects for resection. Extensive fulguration of the resected area and cutting into the bladder wall are other causes of postoperative sepsis. Following operation, continued administration of urinary acidifiers and antibiotics and careful bladder and urethral toilet will prevent infection or keep it under control in most cases. Severe infection is treated by the continued application of the same measures with suprapubic cystotomy in gangrenous cystitis and acute pericystitis, and irrigation of the kidneys or drainage with ureteral catheters when there is evidence of pyelitis with retention of urine.

Following resection, in some cases there may remain residual urine for as long as two weeks after removal of the catheter. This is due to edema about the resected area. Such residual urine encourages infection unless it is drained off and the bladder is thoroughly irrigated at least once a day. When the residual urine has disappeared, the irrigations should be kept up by the gravity method, using a urethral nozzle, until the patient's bladder function has returned to normal, usually in four to six weeks. When there is persistent frequency of urination or when there are shreds in the urine, the occasional passage of a sound and gentle prostatic massage are helpful If residual urine persists, sufficient tissue has not been removed and the resection must be repeated A second operation is always much less difficult than the first.

## PROSTATECTOMY

Prostatectomy may be done by the perineal, the suprapubic, or the retropubic route There are ardent advocates of all routes, though the suprapubic has become the most popular The operation of Young is probably the most satisfactory for removal of the prostate through the perineum. The suprapubic method is simpler and the enucleation following the general principles of the technic of Squiers has given excellent results.

The operator should have the technic of all these methods at his command. In the small fibrous prostate, especially if there is a possibility of malignancy, the perineal route is preferable In the adenomatous prostate projecting largely into the bladder, removal by the suprapubic route seems better. The objections to the perineal route are:

1. It is more complicated and the operation takes somewhat longer to perform.
2. There is a possibility of injury to the rectum and fistula formation.
3 Lack of control of urination may occur unless care is taken not to open the membranous urethra too far forward.

The objections to the suprapubic route are:

1 The removal of the whole urethra contained in the prostate is sometimes followed by stricture.

2. If the prostate is cancerous and very adherent, it cannot be removed satisfactorily.

3. Drainage is less adequate by the suprapubic route and troublesome infe( is more frequent.

The retropubic operation requires more technical skill than the suprap and is less difficult than the perineal. Obesity adds considerably to the difficull retropubic exposure. The operation is particularly useful in cases of large adenc tous prostates that can be done in one stage. In skilled hands a total prostatect is possible by this approach and it has the advantage of a shorter period of pitalization.

The choice of these routes depends somewhat upon the experience of the geon. The operation, particularly the suprapubic, is technically not very diffi though it is essential for the surgeon to have had training in assisting and obser these operations done by one who is skilled in this work before attempting t himself.

It is most important to have the patient in the proper condition to stand operation. The high mortality for prostatectomy in the early history of this opera was partly due to a crude technic but more to the inability to determine the fı tional capacity of the kidneys. When there is much residual urine, the back p sure upon the kidneys gradually alters the conditions under which they func and they gradually meet these changed conditions. A sudden and permanent moval of this back pressure may affect the kidneys profoundly. For this reason patient should either be catheterized or drained for some days or for some w( before a prostatectomy is done. The renal function should be accurately de mined, partly by chemical analysis of the urine, but chiefly by functional test the kidneys. No matter how skillful the operative technic may be, if these pati( *do not show satisfactory renal function disaster is likely to follow. If in doubt,* i wise to drain, either by an indwelling catheter or by suprapubic drainage, until sı a time as the blood urea and phenolsulfonphthalein tests show that the kidneys working satisfactorily.

## Suprapubic Prostatectomy

If suprapubic prostatectomy is to be done in one stage, the bladder should thoroughly irrigated, preferably before the patient leaves the ward, and the cathe left in position. The patient is placed upon the table in the supine position and incision is made extending from just below the umbilicus to a point just above ı pubis. After incising the skin, subcutaneous fat and sheath of the recti muscles, t fibers of the recti and pyramidalis muscles are separated in the midline and t fascia immediately below them is incised, exposing the prevesical fat. At this ti warm boric acid solution may be run into the bladder by gravity until the bladc rises into the lower portion of the wound. The peritoneal fold in the upper porti of the wound is recognized and gently stripped upward with gauze. If the pe toneum is opened, it should be carefully sutured. This area is then protected by gauze sheet either clipped or sutured to the upper angle of the wound. The fat then divided down to the anterior wall of the bladder and pushed to the side ai downward into the space of Retzius. By dividing transversely the thin layer fascia adherent to the anterior wall of the bladder (Fig 970), dissecting the low flap and suturing it to the muscle at the lower angle of the wound (Fig. 971), tl

space of Retzius is protected and troublesome infection in this area is less probable. The bladder is emptied by permitting the fluid to flow out through the catheter, and the catheter is removed. The bladder is opened transversely. After examining the bladder by inspection and palpation, the prostate may be removed by blunt dissection with the index finger or by a combination of sharp and blunt dissection under direct vision. If the patient is quite fat, with a thick abdominal wall, the advantages of vision will not compensate for the disadvantage of trauma caused by efforts to expose the gland. If the former method is selected, the surgeon, if right-handed, inserts his left index finger into the patient's rectum to push upward and fix the prostate. The index finger of the right hand is inserted into the posterior urethra and a suitable area is sought to begin the enucleation. It is usually more satisfactory to break through the mucous membrane just outside the bladder sphincter and near the upper margin of one of the lateral lobes (Fig. 999). If the prostate is not excessively fibrotic, a line of cleavage is easily found at this area. As the lateral lobe begins to separate, the finger is carried posteriorly and downward, separating the hypertrophied tissue from the capsule on that side and posteriorly (Fig. 1000). The urethra at the apex of the hypertrophied mass can then be torn across and the dissection continued along the other side, removing all the hypertrophied tissue in one mass. As the prostate is delivered into the bladder, the base is carefully separated from the mucous membrane at the bladder orifice with as little trauma as possible (Fig. 1001).

When the gland is stuck by adhesions at the apex, separation will be facilitated by grasping the base of the separated tissue with a tenaculum forceps and making strong traction upward. Occasionally, because of the character of the enlargement or adhesions to the capsule, it is easier to separate and remove each lobe separately. If there is no hypertrophied tissue anteriorly, by dissecting forward and backward from both sides of the urethra a portion of the urethral mucous membrane anteriorly may be spared.

When exposure is difficult, it is better to control bleeding from the prostatic cavity by pressure. Either gauze or an inflated bag may be used. If bleeding is profuse, gauze is preferable since it can be made to fit more accurately into the cavity and less intense pressure is required than with an inflated bag. When the bleeding is moderate, a bag of the Foley type is quite satisfactory (Fig. 1002). When the hypertrophied tissue has been removed, it is well to pack the cavity snugly with hot moist gauze for about ten minutes Much of the surface oozing is controlled, and one can determine the amount of bleeding to be controlled If a bag is to be used, the catheter, equipped with a bag, is introduced through the urethra on a mandrin, the bag is inflated sufficiently to fit snugly into the bladder orifice, and traction is made on the catheter until blood no longer trickles into the bladder The catheter may then be strapped to the thigh, making constant elastic tension. If a Hagner bag is used, a sound is passed through the urethra and the tip is inserted snugly into the tube through which the bag is inflated. The sound and tube are withdrawn through the urethra, the bag is inflated, and traction is made in the same manner. After three or four hours of pressure, the bag may be partly deflated and should be completely deflated within twenty-four hours. Prolonged pressure on the internal sphincter may cause incontinence of urine Gauze packing is best applied by using a long roll of two-inch gauze which is molded carefully to the prostatic cavity. The end is left long enough to emerge from the upper angle of the wound



Fig. 999.—Two-stage suprapubic prostatectomy. The wound has been reopened and the superior angle protected by gauze. With the left index finger inserted into the rectum to push the prostate upward, the right index finger is inserted into the posterior urethra and the enucleation is begun near the superior portion of the right urethral wound If the surgeon is left-handed, the enucleation is more easily begun on the left side of the urethra.

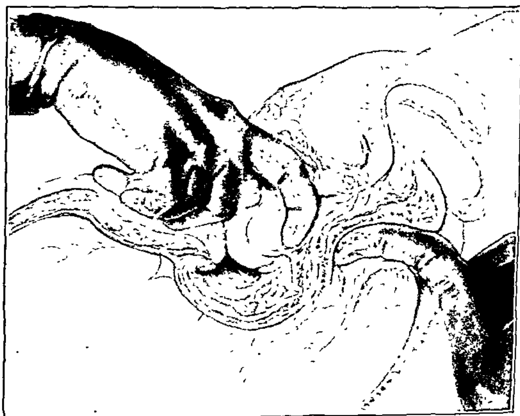


Fig. 1000.—The enucleation has exte[illegible] capsule The posterior urethra has been t[illegible] on the opposite side. From this point the [illegible] cous membrane about the internal orifice of the bladder



Fig. 999.—Two-stage suprapubic prostatectomy. The wound has been reopened and the superior angle protected by gauze. With the left index finger inserted into the rectum to push the prostate upward, the right index finger is inserted into the posterior urethra and the enucleation is begun near the superior portion of the right urethral wound. If the surgeon is left-handed, the enucleation is more easily begun on the left side of the urethra.



Fig 1000.—The enucleation has extended backward, separating the lateral lobes from the capsule The posterior urethra has been torn across and the enucleation continued backward on the opposite side From this point the prostatic lobes are carefully separated from the mucous membrane about the internal orifice of the bladder.

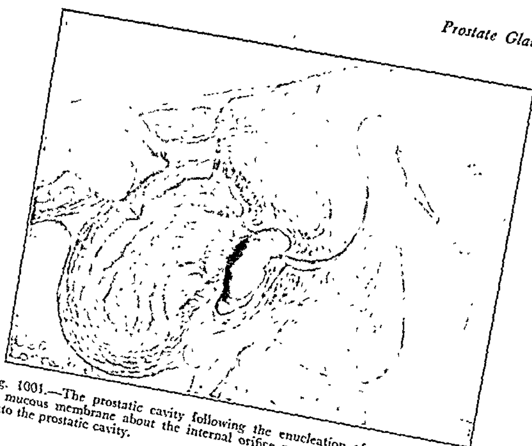


Fig. 1001.—The prostatic cavity following the enucleation of the gland. The ragged edges of mucous membrane about the internal orifice may be trimmed away with scissors or tucked into the prostatic cavity.

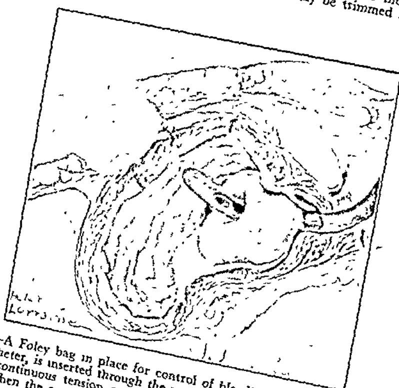


Fig 1002.—A Foley bag in place for control of bleeding. This bag, which surrounds a large urethral catheter, is inserted through the urethra, inflated, and pulled down into the cavity. By making continuous tension *on* the catheter, pressure controls the bleeding. This is very satisfactory when the cavity is not excessively large. When the cavity is very large or the bleeding is extensive, it is best to control the bleeding by packing with gauze. After the bag or packing has been placed, the suprapubic wound is closed with interrupted sutures of 0 chromic catgut in the bladder and silk in the abdominal wound. Space is left at the upper angle for a drainage tube and for the end of the gauze packing

When the bleeding is satisfactorily controlled, the bladder wound is closed by two rows of No. 1 chromic catgut sutures. The first row includes the deeper portion of the bladder musculature and, beginning at the lower angle, is placed so that the mucous membrane of the bladder is turned inward. The suture is tied at a sufficient distance from the upper angle of the bladder wound for the introduction of a drainage tube and, if gauze packing is used, to permit the end of the packing to emerge. A second row of sutures of similar material is placed as a continuous suture and includes the superficial portion of the bladder wall. When this suture is tied, it is well to leave the ends long and pass them through the rectus muscle, one on either side of the incision. This fixes the cystotomy opening to the abdominal wall for a while and makes the reintroduction of a tube easier, should the tube be dislodged the first few days following operation. If a Foley bag or similar instrument is used for the control of bleeding, the bladder wound may be sutured snugly around a small tube at the upper angle of the wound; in fact, in a few cases we have closed the bladder completely, depending upon the Foley catheter for drainage. If gauze or a Hagner bag is used, sufficient space must be left to permit its removal. Therefore, it is best to place a rather large tube in the bladder, alongside of which emerges the end of the gauze pack or a small cord leading from the base of the bag. The abdominal wound should be closed with interrupted sutures of silk, including all the layers down to the bladder, and a few interrupted sutures of 0 chromic catgut to approximate the anterior sheath of the rectus muscles are inserted It is well to place a small rubber drain down to the bladder in the lower angle and to bring it out between the lower sutures. It is removed in about forty-eight hours. If the gauze or the bag is to be removed suprapubically, the two upper silk sutures are not tied until this is done. Following operation the pressure from a bag should be completely released at the end of twenty-four hours, but the inflated bag is left in the bladder a second day for pressure to be applied if bleeding occurs. After forty-eight hours the bag is removed, the urethra is flushed out with an antiseptic solution, and a urethral catheter is strapped in for drainage, permitting the suprapubic fistula to heal. Gauze packing should likewise be removed in forty-eight hours. It is more satisfactory to remove a portion of the gauze twenty-four hours after operation and the remainder a day later, when a catheter may be fastened in the urethra for drainage. Some surgeons prefer suprapubic drainage during convalescence, inserting increasingly smaller tubes as the fistula contracts until finally gauze is depended upon to collect the drainage. It has been my experience that the wound heals more rapidly with catheter drainage and it is used routinely except in patients who do not tolerate it. Often a suprapubic tube is likewise left in place until the urine is free of blood. Regardless of the method of drainage, dry bed linen contributes greatly to a smooth convalescence.

If the patient is not obese or the bladder has not been previously opened, it is not difficult to expose the interior of the bladder, remove the prostate gland, and control most of the bleeding by ligatures or by sutures. After retractors have been placed and the sphincter area is exposed, an incision is made through the mucous membrane and submucosa over the most prominent portion of the prostate as it bulges into the bladder (Fig. 1003). After dissecting the posterior flap of mucosa from the prostate for a short distance, which may be easily done by inserting and spreading the blades of curved scissors, the prostate is grasped with forceps and pulled upward and backward as the dissection is continued with the finger (Fig.

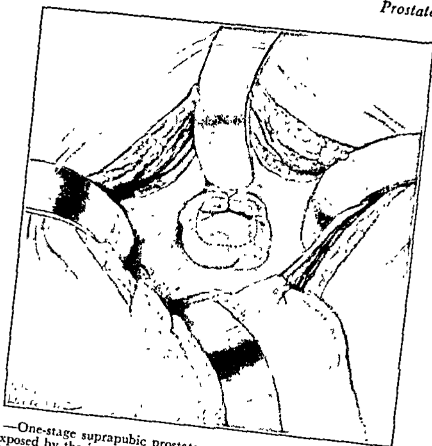


Fig. 1003.—One-stage suprapubic prostatectomy. The bladder has been opened and the prostatic area exposed by the insertion of retractors. The dotted line shows the incision which is made through the mucous membrane over the most prominent portion of the gland. This incision should be carried down through the capsule.

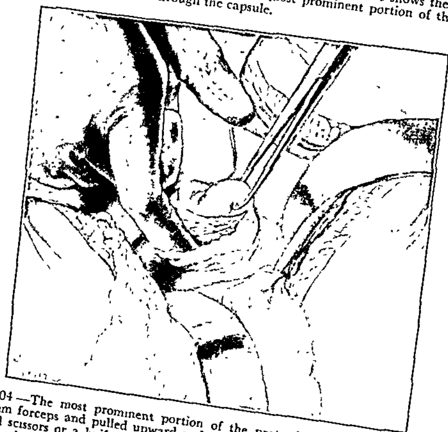


Fig. 1004.—The most prominent portion of the protruding prostate has been grasped with tenaculum forceps and pulled upward and slightly forward. The enucleation here is begun by closed scissors or a knife handle until the finger can be inserted. From this point on the enucleation is done with the finger very much as in the second stage of a two-stage prostatectomy. In rather stout patients where exposure is difficult, it may be helpful to have an assistant insert the finger in the rectum and push the prostate upward.

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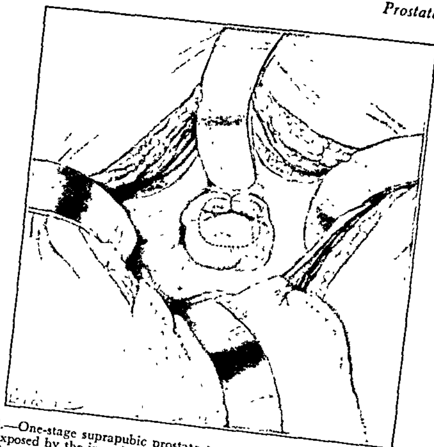


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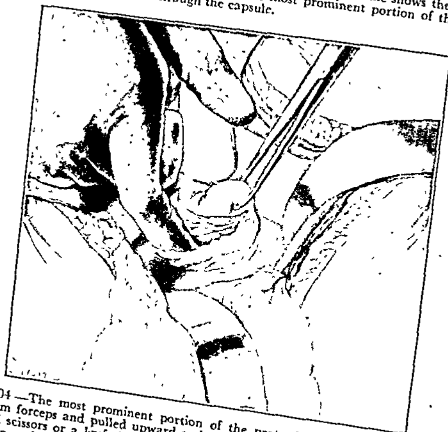


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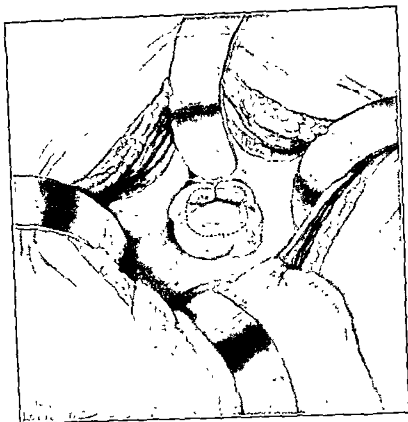


Fig. 1003.—One-stage suprapubic prostatectomy. The bladder has been opened and the prostatic area exposed by the insertion of retractors. The dotted line shows the incision which is made through the mucous membrane over the most prominent portion of the gland. This incision should be carried down through the capsule

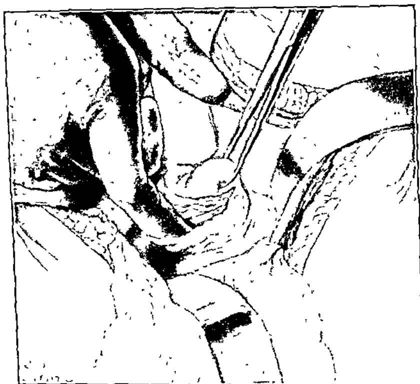


*Fig 1004*—The most prominent portion of the protruding prostate has been grasped with tenaculum forceps and pulled upward and slightly forward. The enucleation here is begun by closed scissors or a knife handle until the finger can be inserted. From this point on the enucleation is done with the finger very much as in the second stage of a two-stage prostatectomy. In rather stout patients where exposure is difficult, it may be helpful to have an assistant insert the finger in the rectum and push the prostate upward.

1004). When the gland has been entirely freed from the posterior capsule, it may be torn or cut from its attachment to the urethra and removed. If there is no enlargement of the anterior lobe, the mucous membrane of the posterior urethra may be incised longitudinally just above the lateral lobe on each side, leaving the anterior urethral wall intact. This is a desirable procedure, but rarely practical. When, as occasionally happens, the hypertrophy is confined to the posterior commissure or to Albarran's glands, the hypertrophied tissue may be enucleated, leaving the entire posterior urethra intact. When the hypertrophied tissue has been removed, the cavity is packed for a few minutes with a sheet wrung out of hot salt solution, which will stop much of the surface oozing. Any bleeding vessels visible should be clamped and ligated. The torn edges are trimmed away and the margin of the mucous membrane is sutured to the prostatic capsule in the posterior urethra (Fig. 1005), care being taken not to suture too deeply for fear of including the

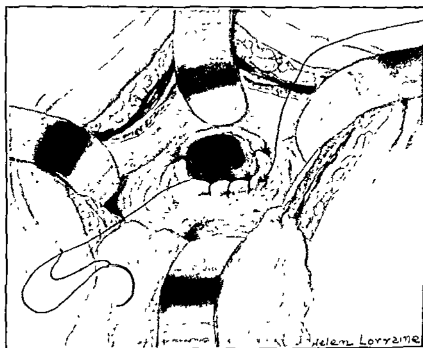



Fig 1005—The prostate has been enucleated and the mucous membrane has been sutured to the prostatic capsule. This suture encourages healing and controls most of the bleeding. The two lateral sutures are taken rather deep. It has been shown by Harris that a large part of the postoperative hemorrhage occurs in these areas. When the sutures have been placed, if there is still appreciable bleeding, it may be controlled by a Foley bag or a small gauze pack. The bladder may be drained with a catheter through the urethra or with a suprapubic tube, or both If the cavity is very dry, frequently it is possible to insert a large cathether and close the bladder completely.

rectal wall. One fairly deep interrupted suture on either side of the orifice, as suggested by Harris, is inserted, and the mucous membrane is closed posteriorly by a continuous suture. Harris suggests sutures across the anterior half of the sphincter, taking bites deep in the fossa. These are difficult to place and are useful only when the sphincter has been widely dilated by the growth of a very large gland. If the bleeding has been controlled, a catheter may be placed in the urethra for drainage and the bladder closed as previously described either entirely or with a small suprapubic tube for accessory drainage until the urine is clear. In most cases there is some oozing from the deeper portion of the fossa and it is better to insert a Foley bag.

When prostatectomy is to be done in two stages, the bladder is exposed as is described for the one-stage operation. If the bladder has been previously examined by cystoscope or by x-ray and cystogram, there is no occasion for examining the interior of the bladder at this time. A No. 26 Pezzer catheter is best for drainage. A purse-string suture is placed in the anterior wall of the bladder, enclosing an area as far from the bladder orifice as practical. A stab wound is made through this area, the catheter with the bulb stretched over a heavy probe is inserted, and the purse-string suture is tied (Fig. 972). The long ends of the suture are brought through the recti muscles near the upper end of the incision and are tied lightly (Fig. 972). The abdominal wound is closed, with the tube emerging near the upper angle.

If the bladder contains stones or diverticula, it is necessary to open the bladder at this first stage. The operation of diverticulectomy is often rather extensive, and, if the patient is not in excellent condition, preliminary drainage is desirable before the operation is attempted. Drainage should be done by an indwelling catheter or by a catheter introduced through a trocar and cannula. Preliminary cystoscopy is not advocated in every prostatic patient. With the knowledge to be gained by x-ray, including intravenous urography and cystogram, there seems little necessity for exploring the bladder at the preliminary operation. It adds to the danger of the operation, often causes infection of the wound, and increases the difficulty of keeping the patient dry during the preparatory period.

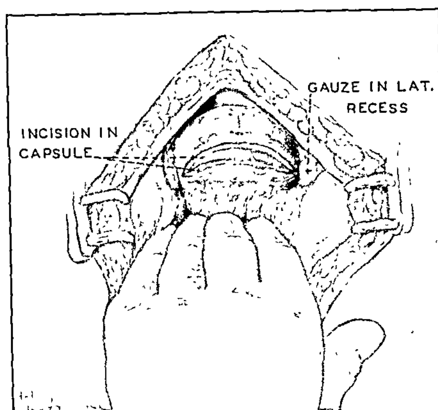
The second operation is begun by making an elliptical incision, removing the old drainage tract down to the bladder. If the preliminary operation has been done only a week or ten days before, this is not necessary, for the previous wound may be opened. The bladder is incised from the cystotomy tube downward until sufficient room is obtained for enucleation and removal of the gland. The anterior wall of the bladder will be found fixed to the neighboring tissues by adhesions or by plastic exudate, depending upon the length of time since the primary operation was done. In thin individuals it is unnecessary to disturb this attachment. The abdominal wall may be depressed and the finger may be introduced into the posterior urethra with very little trauma to the abdominal wound. In obese patients it is necessary to insert the entire hand in the wound, and the unyielding anterior bladder wall will be torn from its attachments and at times into the peritoneum, causing dangerous contamination. It is therefore better in these cases carefully to separate the bladder from the overlying tissues and to protect the upper angle of the wound with gauze. The edges of the bladder wound may then be grasped with Allis forceps and the hand is gently inserted into the bladder before enucleation is begun. Enucleation is carried out as described above, using blunt finger dissection. Efforts to expose the interior of the bladder and prostate to direct vision through the fixed and unyielding abdominal wall that follows suprapubic drainage adds unnecessarily to the time and trauma of the operation. When the hypertrophied tissue has been removed, bleeding may be controlled by gauze or a bag as previously described. The wound cannot be closed as accurately as in a primary incision. It is quite satisfactory to use rather closely placed interrupted sutures of No. 2 chromic catgut in the bladder and interrupted silk in the abdominal wound, leaving space at the upper angle of the wound for the drainage tube and the end of a gauze pack. One or two abdominal sutures are left untied until the packing is removed.

## Retropubic Prostatectomy

Spinal anesthesia is preferable in the retropubic operation because of the relaxation of the abdominal muscles, permitting better exposure. After the patient's bladder has been irrigated and emptied and the lower abdomen prepared, the patient is placed in a moderate Trendelenburg's position. An incision is made, beginning just below the umbilicus and extending downward over the symphysis pubis. After dividing the skin and fascia, the rectus and pyramidalis muscles are separated and retracted laterally, exposing the anterior fold of the peritoneum and the perivesical fat. It is well at this time to ligate or suture all bleeding areas in the muscle or fascia. A self-retaining retractor is then placed in position. With the finger, the loose perivesical fat is separated and drawn upward with the peritoneal fold and held in place with the posterior blade of the self-retaining retractor or with a slightly angulated spatula. *This exposes the anterior surface of the prostatic* capsule. Loose fat adherent in this area is gently pushed forward. Several large veins are seen running along the anterior and lateral aspects of the prostate. Gauze is packed gently on either side of the prostate to elevate and stabilize the gland All visible prostatic veins are doubly ligated by underrunning them with needle and plain catgut. It is well to take a fairly deep bite in the prostatic capsule to prevent tearing the vein. These ligatures may be cut or left long and the ends held with hemostats for traction It is best to take a deep suture in the capsule on either side, *about where the ends of the transverse incision in the capsule are to be. These* sutures with the ends left long for traction aid in elevating the prostate and in the control of capsular bleeding.

A transverse incision is made in the anterior surface of the prostate about 1 cm. distal to the bladder neck between the ligatures that control the large superficial veins, down through prostatic capsule until the adenomatous tissue is recognized. The incision extends almost across the anterior surface of the gland (Fig 1006). Blood vessels encountered in the prostatic capsule should be clamped and transfixed with needle and catgut or fulgurated. *Continuous suction aids in identifying the* bleeders.

The plane of cleavage between the false capsule of the prostate and the hypertrophied tissue is located by the tip of a pair of curved scissors. The index finger is then introduced and the enucleation continued as in a suprapubic prostatectomy, *extending the dissection first toward the apex of the gland.* If the urethra does not separate easily from the apex, it is divided with scissors. The apex of the gland is then delivered through the capsular incision and grasped with a tenaculum or sponge-holding forceps and *the dissection is continued toward the bladder.* After releasing the gland from the bladder orifice, any attachments or tags are excised. The prostatic fossa is packed with gauze while the margins of the capsule and bladder orifice are examined. If there are bleeding vessels, they are clamped and ligated. A catheter is then passed into the urethra and its end is guided through the bladder orifice Millen used a straight catheter. Lowsley recommends a No. 24 Foley catheter with the 30 c.c. bag covered with Gelfoam soaked in thrombin. The tip of the catheter projects into the bladder. The bag is distended as necessary to make *even pressure in the prostatic cavity.* A No 20 Foley catheter with a swath of oxidized gauze fixed to the catheter about 5 cm. behind the tip is frequently used. The gauze remains in the fossa, and this gives adequate hemostasis and excellent




g. 1006.—Retropubic prostatectomy. Dorsal veins have been ligated and prostatic capsule has been incised.

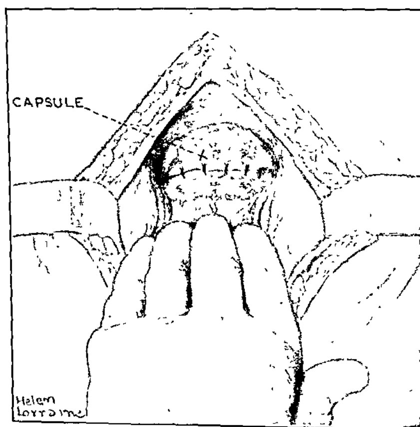



Fig 1007.—Retropubic prostatectomy. Capsule is sutured.

drainage. When the catheter is in place, the capsule is closed with continuou closely placed sutures of 0 chromic catgut (Fig. 1007). Any ligatures that h been left long are tied together over the line of suture. All gauze is removed f the wound and a small rubber tissue drain is placed in the space of Retzius. wound is closed as following a one-stage suprapubic prostatectomy.

Millen has devised a complete set of instruments including forceps, retract and boomerang needle-holder for this operation. Instruments in routine use be adequately substituted for them. It is felt that the surgeon is handicapped w he relies too much upon specialized instruments.

## Perineal Prostatectomy

Although perineal prostatectomy requires a more careful technic and is m difficult to execute, it has a number of important advantages Drainage is bet which is a very important factor particularly in obese individuals. It is the

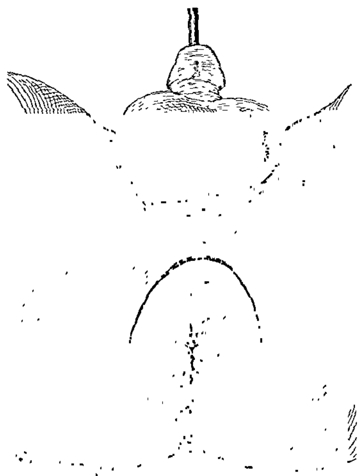


Fig. 1008.—Curved incision for perineal prostatectomy.

means by which an early cancer may be treated with any hope of cure and has co siderable advantage in the management of fibrous prostates and those contain stones. The surgeon who learns the technic of this procedure will use it in majority of his cases in which prostatectomy seems indicated.

The patient should be placed in an exaggerated lithotomy position with thighs drawn well back and the perineum as nearly parallel to the thighs as p sible and so held that there will be no shifting of the position. This greatly fac tates the operation. After preparing the perineum and external genitalia and jecting an antiseptic solution through the urethra, a sound is passed until its be

rests well within the posterior urethra. The sound is held in this position by an assistant. The prostate is approached through the space between the ischiopubic rami and behind the triangular ligament. An inverted U incision is made with the central position about 3 to 4 cm. in front of the anus and the limbs running backward about 5 cm. on each side within the ischiopubic rami (Fig. 1008). The skin,

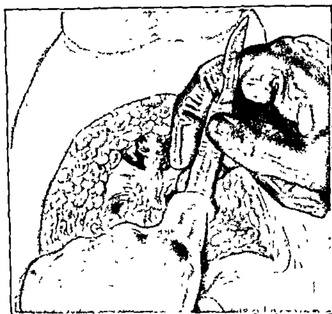


Fig. 1009.—Perineal prostatectomy. The central tendon, urethral bulb, and transversus perinei muscle are exposed. With the finger and handle of a knife the cellular spaces posterior to the transversus muscles and in front of the rectum are opened and the rectum pushed backward.

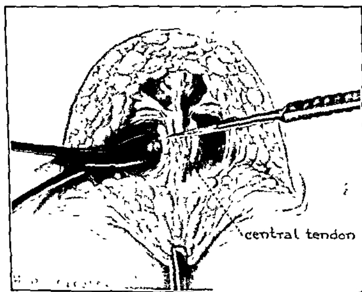



*Fig 1010*—The central tendon has been isolated and is being cut transversely.

fat, and subcutaneous fascia are divided and the bulb is exposed. Care must be taken not to incise the bulb because of troublesome bleeding. By blunt dissection, using the finger and handle of the scalpel, the space on each side of the central tendon behind the transversus perinei muscles and in front of the levator ani is opened. By directing the dissection slightly upward and forward the rectum is avoided (Fig. 1009).

A special bifid retractor is placed posteriorly or the index and middle fingers are inserted one on each side of the central tendon and slight traction is made, drawing the bulb well into view and pushing the rectum backward. The central tendon is then isolated and cut across close to the bulb (Fig. 1010), exposing the rectourethralis muscle, which runs from the rectum to the membranous urethra and triangular ligament. The rectum is then retracted backward by a right angle retractor making slight tension on the rectourethralis muscle (Fig. 1011). This

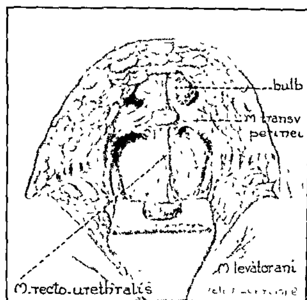



Fig. 1011.—The central tendon has been divided, exposing the rectourethralis muscle, which is to be divided near the urethra, thereby exposing the apex of the prostate.

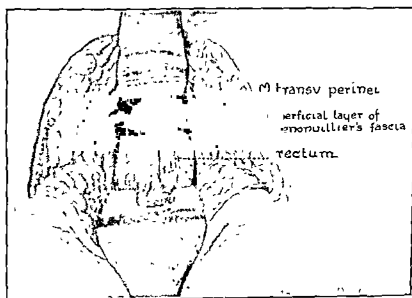



Fig. 1012.—The bulb of the urethra and transversus perinei muscles are being retracted forward, exposing the apex of the prostate covered by Denonvillier's fascia

muscle is carefully divided close to the membranous urethra, and the rectum, which can be recognized as a small pouch near the urethra, is pushed back gently and carefully with the handle of the scalpel. The membranous urethra and apex of the prostate are thus exposed (Fig. 1012). Care must be taken not to injure any of the circular fibers of the membranous urethra A small grooved retractor which

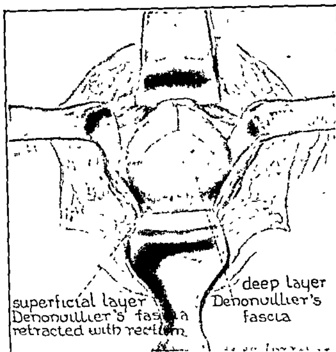



Fig. 1013 —With a right angle retractor posteriorly protecting the rectum, and small retractors laterally pulling the levator ani muscles aside, the base of the prostate is exposed. The superficial layer of Denonvillier's fascia has been stripped back. The dotted lines show the outline of the incisions for removing the gland.

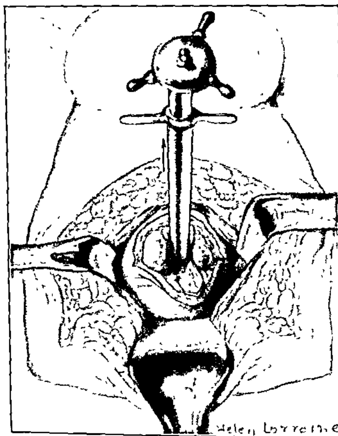



Fig. 1014 —The incisions shown in Fig. 1013 have been carried through the capsule of the prostate, exposing the hypertrophied lobes A prostatic retractor has been inserted and by being pulled backward and upward brings the gland prominently into the wound. On the inner surface of the posterior flap can be seen the mucous membrane of the posterior urethra, including the verumontanum. This flap of mucous membrane is cut across proximally to the verumontanum with the hope of preserving the ejaculatory ducts.

encircles the membranous urethra is inserted. By anterior traction the triangular ligament and membranous urethra are drawn forward, bringing the apex of the prostate more clearly into view. The urethral sound may then be introduced into the bladder, and by pressing the base of the curve against the base of the prostate,

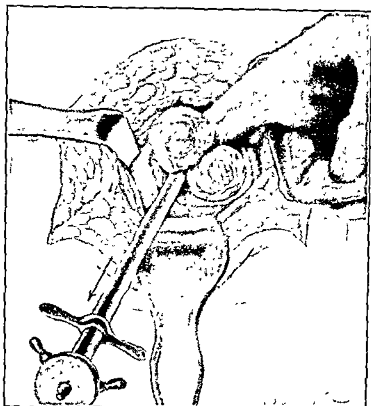


Fig 1015.—The prostatic retractor is used to manipulate the lobes of the prostate into an accessible position. They are enucleated with the finger. The enucleation is started with closed scissors or the handle of a knife.

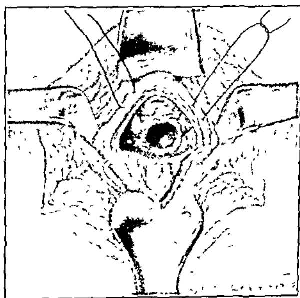


Fig 1016.—The prostate gland has been removed. At the upper angle of the wound the stump of the membranous urethra is seen. *Below this* [illegible] der. Interrupted mattress sutures placed around [illegible] of the prostate, then tied, close the prostatic cav [illegible] packing After a catheter is passed through the [illegible] into the bladder, the posterior flap is sutured in place with interrupted sutures.

the posterior surface of the gland will present more prominently into the wound. The posterior layer of Denonvilliers' fascia is carefully incised at the apex of the prostate and gently stripped from the posterior surface of the gland by blunt dissection, carrying the rectum backward with it. A short longitudinal incision is then made into the posterior urethra through the apex of the prostate (Fig. 1013). In this way the membranous urethra is entirely avoided and the danger of incontinence minimized. The sound is removed and a prostatic tractor is introduced through this wound into the bladder and the blades are opened. Backward and upward traction with this instrument after removing the anterior retractor brings the posterior surface of the prostate, covered by the smooth posterior layer of Denonvilliers' fascia, well into view. A right-angled retractor is inserted posteriorly to draw back and protect the rectum, and two small lateral retractors are helpful in drawing aside the levator ani muscles. Two incisions are made downward and outward from the incision previously made in the apex of the prostate, dividing the capsule and the lateral walls of the posterior urethra. A triangular flap can be turned down; it is lined on its upper surface by the floor of a portion of the posterior urethra, including the verumontanum (Fig. 1014). A short incision is then made in the base of this flap well proximal to the verumontanum with the hope of preserving this structure and the ejaculatory ducts. These incisions expose the hypertrophied lateral lobes which are enucleated by blunt dissection, using at first the handle of the scalpel or blunt scissors and later the finger. While enucleating the prostate one hand guides the prostatic tractor in such way as to bring each portion of the hypertrophied gland more easily within reach (Fig. 1015). Enucleation may at times be accelerated by making traction on the partly freed mass with sponge-holding forceps When enucleation is finished, the finger should be inserted into the bladder and the orifice examined. If any of the hypertrophied gland is left, such as an isolated median lobe, it may be forced into the prostatic cavity and removed. Bleeding is controlled by packing or by suture. It seems more satisfactory to suture the bladder wall near the orifice to the prostatic capsule (Fig. 1016) and insert a Foley bag, which by traction provides hemostasis and affords drainage. If the bleeding is excessive, the cavity may be packed snugly with a narrow gauze strip and a bag placed through the urethra to make pressure against the packing. Some operators consider it safer to place a tube through the perineal wound for a couple of days as an accessory drain to the catheter in the prostate while some depend upon perineal drainage entirely. The wound heals a little more quickly if the bladder is drained through the urethra.

When the bleeding has been controlled, whether by suture or gauze, the triangular flap from the posterior surface of the prostate is sutured back with interrupted sutures of catgut and the levator ani muscles are approximated in the midline in the same manner; this adds protection to the rectum. If drainage tubes or gauze are used, they are brought out anterior to the sutures of these muscles and through one angle of the wound If no packing is used, it is well to place a small gauze wick up to the prostate. The central tendon may be approximated by interrupted catgut sutures although this is not essential The perineal wound is closed with interrupted sutures of silk, leaving an area at one angle for drainage. Packing or perineal drains should be removed in about forty-eight hours. If a catheter bag is used for drainage and hemostasis, the pressure should be released in twenty-four hours and the catheter left in place for drainage.

## CARCINOMA OF PROSTATE

In cancer of the prostate a more radical operation must be done. Young has devised a technic for radical operation which seems satisfactory from the standpoint of a cure and at the same time gives the patient a moderate degree of urinary control after the operation. The patient is placed in the extreme dorsal position as in the perineal operation for prostatectomy and the procedures are carried out as though a perineal prostatectomy were to be done, up to the step of incising the capsule. After inserting the tractor the prostate is drawn down and the posterior layer of Denonvilliers' fascia is divided at the apex of the prostate on each side, thus exposing the anterior layer of this fascia which covers the prostate and the seminal vesicles (Fig. 1017). The posterior surface of the prostate and seminal

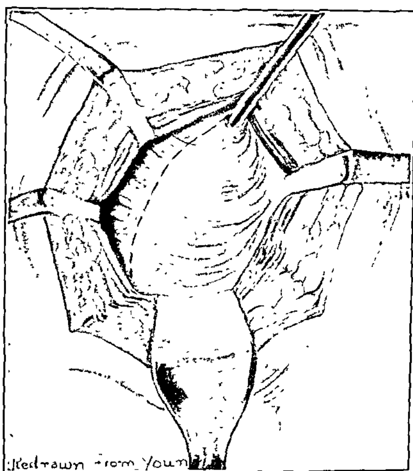


Fig. 1017.—The operation of Young for cancer of the prostate. The urethra has been opened through the perineal incision, the tractor is inserted into the bladder, and the posterior surface of the prostate is cleared, showing the anterior layer of the fascia of Denonvilliers The dotted line shows where the dissection should proceed in order to keep between the anterolateral fascia and the lateral aspect of the prostate

vesicles is freed and then the lateral surfaces of the prostate are exposed by blunt dissection. The operator keeps within the anterolateral prostatic fascia, separating it from the prostate, which thus avoids hemorrhage and at the same time preserves the vascular supply and the perineal nerves. This step Young thinks is very important. By incising the anterolateral fascia and passing between it and the lateral and the anterior part of the prostate, a certain amount of urinary control can be preserved After separating this fascia the membranous urethra is completely

divided just in front of the prostatic tractor. Here also the anterolateral prostatic fascia must be respected. The prostate is pulled down and gradually drawn outward (Fig. 1018).

The bladder wall is incised anteriorly, close to the upper limit of the prostate, and the incision is continued by scissors on each side. In this manner the trigone of the bladder is fully exposed. The trigone is incised about 1 cm. below the ureteral orifice, in such a way that the walls of the bladder are carefully cut through but the seminal vesicles beneath are not divided. The bladder is then pushed up bluntly, thus exposing the tissues around the front of the seminal vesicles and vasa deferentia. These structures are freed en masse and the fascia which contains the

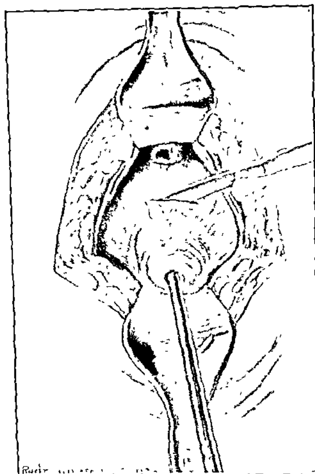


Fig 1018—The membranous urethra has been completely divided The prostate is turned down and the bladder wall is incised just above the upper limit of the prostate.

blood supply at the upper end of the seminal vesicles on each side is ligated and divided as far as possible from the prostate. The vas deferens is isolated on each side, freed well above the tip of the seminal vesicle, drawn down, clamped and divided (Fig. 1019). The mass including the prostate and its surrounding tissue is then removed in one piece.

The bladder is drawn down and the upper portion of the urethra is sutured to the upper portion of the wound in the bladder by interrupted sutures of chromic catgut and tied externally (Fig. 1020). A catheter is then inserted through the urethra and into the bladder, and the anastomosis between the urethra and the bladder is completed by interrupted sutures of chromic catgut. The longitudinal

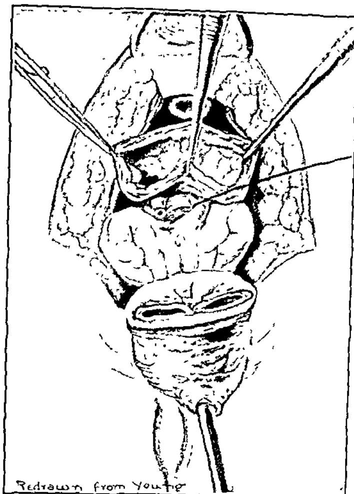



Fig 1019.—The bladder has been completely incised, the vesicles, the vasa, and the surrounding tissue are mobilized, and the right vas is divided and tied. Vascular tissues in this region are clamped, if possible, before division.

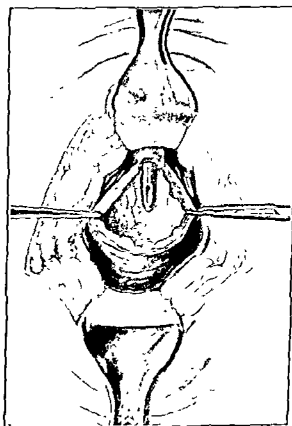


Fig 1020—The prostate with the surrounding tissue is removed in one mass and the upper border of the bladder wound is sutured to the upper part of the urethra with interrupted sutures of chromic catgut, and the knots are tied externally. Similar sutures are placed anteriorly and the rest of the bladder wound is closed with a continuous suture.

opening in the bladder, which remains posterior to the anastomosis, with the urethra is closed with a continuous suture of chromic catgut. A small cigarette drain of iodoform gauze is placed behind the line of sutures, and the levator ani muscles are brought together by one or two sutures of chromic catgut. The skin is closed in the usual manner. The catheter is left in and fastened to the penis by adhesive plaster. The drainage is removed in two or three days. It is not necessary to pass sounds or instruments after the operation.

In Young's experience many patients after this operation have satisfactory control of the bladder.

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# CHAPTER 73

# THE SEMINAL VESICLES, VAS DEFERENS, TESTICLE, TUNICA VAGINALIS, AND SPERMATIC CORD

AUSTIN I. DODSON

## THE SEMINAL VESICLES

Disease of the seminal vesicles *may require operation for drainage or, occasionally*, for excision of the seminal vesicles. In either case the technic of exposure of the vesicles is the same. The patient is placed in the exaggerated perineal prostatectomy position, and an incision is made similar to that used in perineal prostatectomy. The operation proceeds as in perineal prostatectomy, with blunt dissection on each side of the central tendon and division of the tendon and the recto-urethralis muscle. The membranous urethra and apex of the prostate are now exposed. The urethra is not opened as in prostatectomy, but the prostate and vesicles are pulled forward by a double tenaculum hooked into the base of the prostate, or by Young's long urethral retractor. A sound or Young's long urethral retractor is inserted into the urethra.

The fascia that covers the apex of the prostate is divided and stripped back by blunt dissection, together with fibers of the levator ani muscle which are at*tached to the base and lateral surfaces of the gland. A double tenaculum* is now inserted into the base of the prostate for retraction, or if Young's retractor is used, the blades are opened and the handle pulled forward and upward to bring the seminal vesical area into view. By blunt dissection the rectum is freed well behind the prostate, exposing the vesicle area and the base of the bladder. The rectum is protected by a gauze pad and held back by a long, flat, right angle retractor, about 4 cm. wide. Narrow retractors in the sides of the wound will aid the exposure. As the prostate is pulled forward, Denonvillier's fascia is divided near the base of the gland and stripped away by blunt dissection, exposing the vesicles and the vas deferens. The *vesicles may now be excised or drained. Unless exudate or adhesions* interfere, the vesicles should be separated from the vas deferens and base of the bladder, ligated at the base of the prostate, and removed. If the vas is thickened or the ampulla dilated, it should be incised and drained. When exudate and adhesions prevent excision of the vesicles, their posterior walls are trimmed away with scissors, leaving the anterior walls attached to the bladder; or if preferred, the posterior walls may be incised throughout their entire length. If the vesicles are incised or the posterior walls removed, small, soft rubber tubes with many perforations should be sutured to the remaining vesicle walls. If the vesicles are removed, the tubes

should be secured to the vas deferens. If necessary, the prostate may be incised and drained, or partly removed, at the same time, but the bladder or urethra should not be entered if it is possible to avoid it. Before the wound is closed, the base of the bladder, the peritoneum in the depth of the wound, and the rectum should be carefully examined, and if injured, should be immediately repaired. The wound is closed by suturing the levator ani muscles together below the drainage tubes which are brought out at one angle of the wound. The divided rectourethralis and the central tendon are sutured with chromic catgut and the superficial fat and skin with interrupted sutures of silk. A firm dressing is applied.

When the seminal vesicles are to be opened, the operation of Fuller has given good results. The patient is placed in the knee-chest position with the knees sharply flexed. An incision is made on each side of the anus, opening up each ischiorectal fossa, and the extremities of these incisions are joined by a transverse incision in front of the rectum With the left finger in the rectum as a guide and protector, the rectal wall is separated from the prostate and vesicles by blunt dissection. After the separation a long grooved director is thrust into the apex of the vesicle while using the finger in the rectum as a guide to direct the course of the director. A scalpel is shoved along the groove of the director until it enters the apex of the seminal vesicles and a cut of about 3 cm is made with the blade of the knife along the course of the vesicle, freely laying open its cavity. The incision is dilated with the finger tip. The other seminal vesicle is opened in a similar manner. If there is a considerable mass of granulation tissue, the cavity is curetted. Each cavity is packed with strips of gauze, the ends of which protrude from the external wound, and two soft rubber drainage tubes are placed between the gauze and the rectum. The incision is closed with interrupted sutures except at the transverse part which is left open for drainage and for the exit of the tubes and the ends of the gauze packing. The gauze is removed after three days and the tubes four days later.

## VAS DEFERENS

Operations upon the vas deferens consist of partial or complete excision, vasotomy, and ligation. Excision of the vas is discussed with operations upon the seminal vesicles and the epididymis.

The vas deferens is readily exposed in the upper portion of the scrotum by isolating and approximating it to the skin with the thumb and forefinger, and making a short longitudinal incision through the skin, fascia, and dartos, exposing the vas. If one prefers, a large curved needle may be passed through the scrotum beneath the vas to steady it. After the vas is exposed, it is freed by blunt dissection and brought into the wound It may then be incised or divided and ligated, according to indications. The vas is usually incised for the purpose of inserting a needle to irrigate the seminal vesicle, according to the method popularized by Belfield for the treatment of seminal vesiculitis. In this method of treatment, after the needle has been inserted either through an incision or by puncturing the vas (which is more difficult), a fine horsehair or silkworm-gut suture is passed through the needle and the proximal portion of the vas to determine its patency. The horsehair or silkworm-gut is withdrawn and the antiseptic solution is then injected through the vas, a portion of it regurgitating into the seminal vesicle. Some operators leave the

needle in place several days for repeated irrigations. This operation is bene in many cases of seminal vesiculitis, though it carries the risk of occluding the l of the tube.

Vasotomy may be done to determine the patency of the tube, and this is ried out as described above, or by gently injecting through the vas a colored sol to be expelled from the bladder. Ligation of the vas is occasionally done fo treatment of recurrent epididymitis, as a means of birth control, and frequentl the prevention of epididymitis following prostatectomy. The vas is doubly li and divided between the ligatures. It is a good practice to use the ends o ligatures to fix the divided ends to the extremities of the scrotal wound. The w in the scrotum is closed with one or two interrupted sutures of silk and a gauze dressing is fixed in place by collodion or held on by a suspensory.

## Anastomosis of the Vas Deferens

Anastomosis of the vas with the epididymis is done in sterility, in which is a blockage of some portion of the vas or of the epididymis. The epididymi vas may be satisfactorily exposed through an incision in the posterior part o scrotum. The veins and larger blood vessels should be avoided Before unde ing this operation any stricture that may be in the urethra or inflammation o seminal vesicles should be cured and the patency of the vas from the epididym the prostatic urethra should be demonstrated by injecting methylene blue inte vas and noting if it appears in the urethra. The vas is exposed and split longi nally and about twenty or thirty drops of methylene blue are slowly injected. dye will appear in the urine if there is no obstruction or in the seminal disch after massage of the seminal vesicles If this test shows obstruction, the epidid is opened by cutting off a small piece with a pair of scissors. It must be der strated by a microscope that the fluid within this portion of the epididymis con spermatozoa, and if they are not found at this point other openings must be n into the epididymis or into the testicle until spermatozoa are found. The wi split vas is then sutured with a few interrupted sutures on a fine needle to the o ing in the epididymis or testicle. Arterial silk is an excellent suture for this pur

Anastomosis of the vas and the epididymis done by the method descri which was devised by Martin, is more or less indirect. After the capsule of epididymis has been incised and a portion of the epididymis tubule cut, the va split and the open incision in the vas is sewed to the capsule of the epididymis the raw surface of the incised tubule of the epididymis. There is consequently siderable distance to be bridged by the epithelium lining the vas and the epididy

Lespinasse, of Chicago, has devised an operation which is a direct anasto sis between the epididymis tubule and the vas. An incision is made in the scro and through the tunica vaginalis The epididymis is exposed and the point obstruction is found. The vas is opened by a short longitudinal incision, an colored fluid, such as methylene blue, is injected into the central end of the If the fluid appears in the urethra, it is a demonstration that the vas is open fr the point of incision to the urethra, and the operation can proceed. If the vas is open, the operation, of course, will be abandoned unless the point of occlusion be found. If the operation is to be completed, the capsule of the epididymis ab

the obstruction is carefully incised down to the tubule. All of the layers of the capsule are removed from the epididymis tubule with great care and the epididymis tubule itself should not be injured or opened at any point. It protrudes through the opening thus made and a loop of the tubule is selected whose direction is in the long axis of the body of the epididymis. A suture of fine arterial silk (five 0) on a No. 19 bayonet pointed needle is passed through the wall of the epididymis tubule, down its lumen, and out again through the wall of the tubule about 3 mm. from

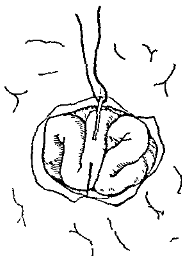


Fig. 1021.

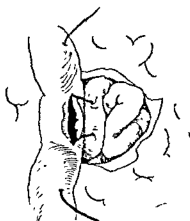


Fig. 1022.

Fig. 1021.—The operation of Lespinasse for anastomosis of the vas and the epididymis. A fine silk suture is inserted into a tubule of the epididymis

Fig. 1022.—The suture in the tubule is carried through the incision in the vas.



Fig 1023.—The other sutures are placed to hold the vas to the capsule of the epididymis.

the point of entrance (Fig. 1021). This is followed by leakage of epididymal secretion which is drawn into a small syringe and examined for spermatozoa. If spermatozoa are present, this suture is passed through the incision that has been previously made into the vas and out through its wall. The other end of the suture is threaded into a needle and passed through the wall of the vas in a similar manner at the other end of the incision in the vas. In this way the epididymis tubule is drawn into the longitudinal incision in the vas (Fig. 1022). Sutures of catgut are placed on each side of the longitudinal incision in the vas, include the full thickness of the wall of the vas, and are carried to the capsule of the epididymis. These hold open the incision in the vas. Two other sutures are placed into a portion of

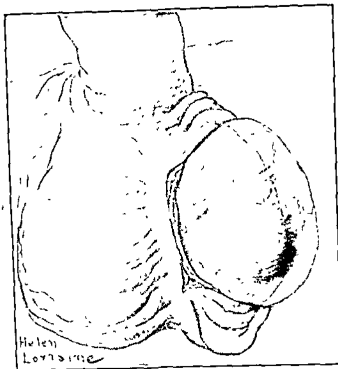



Fig 1025.—The scrotum and scrotal fascia have been dissected from the tunica vaginalis

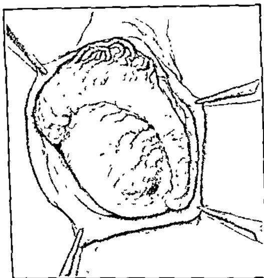


Fig. 1026.

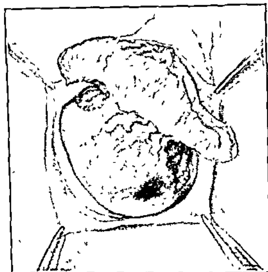


Fig 1027

Fig. 1026.—The tunica vaginalis has been divided, exposing the testicle and diseased epididymis

Fig 1027.—Excision of the epididymis. The two poles of the epididymis have been dissected from the testicle.

traction the structures of the cord are recognized and injury to the vessels may be avoided The dissection is continued by separating the vas up to the internal ring (Fig. 1028). Here it is doubly clamped and divided, the proximal end is cauterized with carbolic and ligated. Any other foci of the disease are excised. After controlling the bleeding by suturing the tunica (Fig. 1029) and the raw surface with catgut, the external wound is closed with interrupted or continuous mattress sutures of fine chromic catgut.

the wall of the vas but do *not penetrate to its lumen or epithelial lining* and hold the vas to the capsule of the epididymis a short distance from the ends of the longitudinal incision into the vas (Fig. 1023). When these two sutures are tied, they should leave the intervening segment of the vas without tension so that the union between the vas and the epididymis tubule is in accurate approximation and without strain. The upper end of the original suture is threaded on a long Hagedorn needle, and *after the testicle has been replaced in the scrotum the needle* pierces the scrotum from within outward. In from one to two weeks, when the wall of the epididymis tubule within the grasp of this suture has become cut by this suture, it is gently removed.

## TUBERCULOSIS OF THE EPIDIDYMIS

*In tuberculosis of the epididymis, the epididymis can often be excised without* removing the body of the testicle, if the disease is not too far advanced. An incision is made through the scrotum (Fig. 1024), external to the epididymis, or if the

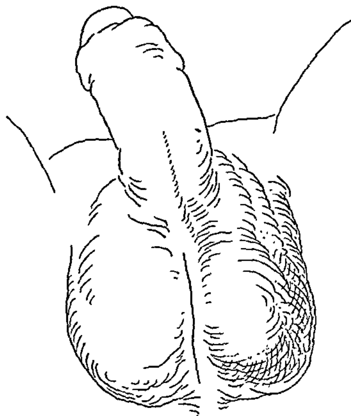


Fig. 1024.—Scrotal incision for exposure of either testicle. Fewer and smaller blood vessels are encountered in this area.

epididymis is adherent to the skin, the tissue that is bound by the adhesions is included in an oval incision. An incision along the junction between the epididymis and testicle is made on the outer side and divides only the tunica vaginalis opposite the body of the epididymis but goes deeper at the globus major and globus minor. The head of the globus major is separated by sharp dissection from the testicle and then the body *of the epididymis is freed (Figs. 1025, 1026, and 1027).* All of this dissection is from the outer side. On the inner side the large vessels to the testicle are in contact with the epididymis and dissection here must be particularly careful. By

The vas is then doubly ligated, divided, and the stump is cauterized. The spermatic vessels are followed up into the lumbar region, all of this being done extraperitoneally. They are doubly ligated and divided. The other tissues of the cord are divided and the cord is dissected down to below the external inguinal ring. The testicle with the tumor and surrounding tissues is delivered into the wound and removed along with the cord. As much tissue as possible is taken, and if any part of the scrotum is adherent this portion should be removed along with the testicle, the original incision being continued downward to include the adherent part of the scrotum. Every bleeding point is clamped and tied with fine catgut.

## Undescended Testicle

The treatment of undescended testicle is no longer exclusively a surgical problem. The growth of the genital organs may be stimulated by the administration of an anterior pituitary-like substance. In a number of reports descent of the testicles has occurred during the administration of such extracts.

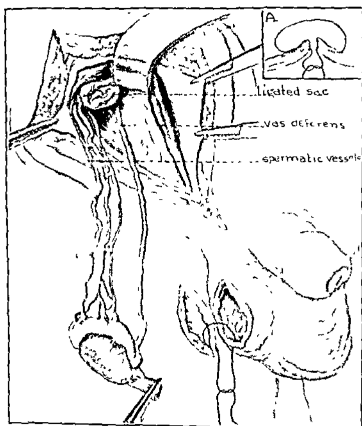



Fig 1030.—Torek's meth[illegible] as been removed and the stump ligated The cord has b[illegible] e can be brought into the scrotum The scrotum has bee[illegible] the scrotum and skin of the thigh preparatory to sutur[illegible] t shows method of suturing posterior edge of scrotal wound to that of thigh so that skin margin will turn out.

In the surgical treatment of undescended or misplaced testicle, the general principles of the Bevan operation are usually applied. Here the incision is made as in the radical operation for inguinal hernia and does not involve the scrotum. After exposing the inguinal canal the cremaster muscle and the fascia are divided, the sac of peritoneum which contains the testicle is opened and the undescended

In epididymitis incision of the epididymis often gives relief when nothing else will. It will probably require a general anesthetic. An incison is made through the scrotum either over the epididymis or in the upper front part of the scrotum so that the testicle can be delivered into the wound. The epididymis is punctured a number of times with a large needle and returned to the scrotum. If there is suspicion of pus, the scrotum is incised immediately over the epididymis, which is punctured in several places.

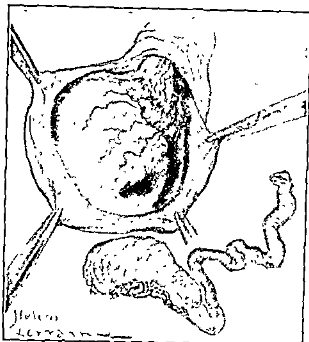


Fig. 1028

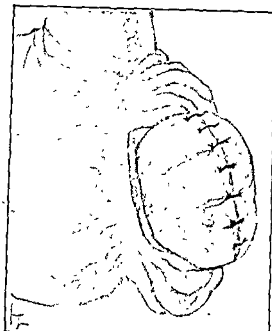


Fig. 1029.

Fig. 1028 —The excision is complete, including a portion of the vas deferens In tuberculous cases the vas should be removed to the inguinal canal and the proximal end fixed to the surface of the skin through a stab wound.

Fig 1029 —The tunica vaginalis is sutured over the testicle. The scrotum is closed and a small rubber tissue drain is placed down to the tunica vaginalis.

## THE TESTICLE

### Orchiectomy

Removal of the testicle may be necessary for tuberculosis or for a benign or malignant growth. An incision is made over the front upper part of the scrotum from the level of the external abdominal ring downward for a sufficient distance to deliver the diseased testicle into the wound. Such an incision is usually all that is necessary in tuberculosis or in benign tumors. The cord is doubly ligated with catgut after being crushed and the testicle is drawn up into the wound and removed It is necessary to clamp and tie every bleeding point. The wound is closed by a continuous mattress suture of fine catgut.

If there is distinct malignancy the operation should be more radical. An incision is made over the inguinal canal from a point 2.5 cm. external to the internal ring, downward over the external ring, and onto the scrotum. The inguinal canal is exposed as in the operation for hernia and the flaps of the aponeurosis of the external oblique are retracted. The vas is dissected from its bed and followed as far as possible into the pelvis after dividing the posterior wall of the inguinal canal

When it is impossible to bring the testicle into the scrotum by this means, some of the spermatic vessels which are the chief obstacle to its descent may be divided. This, however, is of doubtful expediency, for while the testicle may not actually undergo gangrene, division of the spermatic vessels so profoundly affects its nutrition that it will probably atrophy. Gessner has demonstrated experimentally that atrophy of the testicle follows ligation of the spermatic vessels.

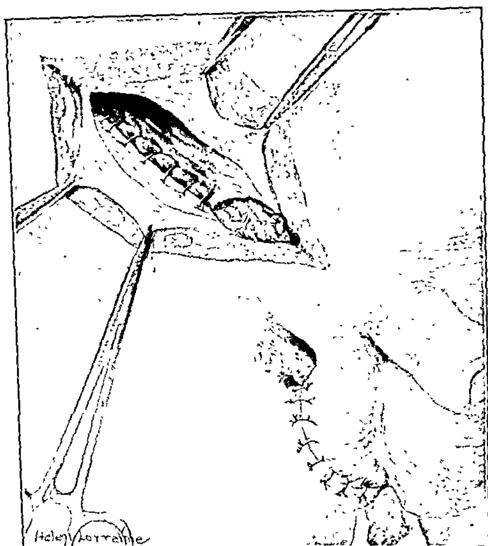



Fig. 1032.—The anterior lip of the scrotal wound has been sutured to that of the thigh, securely covering the testicle. Closure of the abdominal wound completes the operation. The testicle is separated from the thigh three or four months later.

Torek's method of orchidopexy is somewhat more tedious and time-consuming, but the late results are usually satisfactory. The cord is lengthened and the hernia repaired as in the Bevan operation. When the testicle can be brought down to its normal position, an incision about 4 cm. long is made down to the fascia lata on the inner surface of the thigh obliquely from above downward and inward, and at a point where the testicle will lie without undue traction. The fingers are inserted into the scrotum from the inguinal wound to stretch the scrotum and prepare a pocket to receive the testicle. An incision about 4 cm. long is then made in the lower outer portion of the scrotum extending into the cavity. The posterior edge of the scrotal wound is then sutured to the margin edge of the thigh wound (Fig. 1030). Since this row of sutures will be inaccessible, absorbable sutures should be

testicle exposed. The peritoneum above the testicle is separated from the cord very carefully and the upper portion is divided and closed by sutures or a ligature as in closing the neck of a hernial sac. The lower pouch of peritoneum serves as a tunica vaginalis and is sutured over the testicle loosely with a purse-string suture.

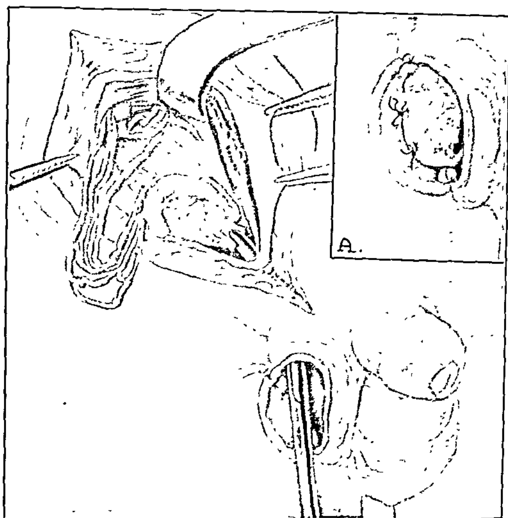



Fig. 1031.—Forceps inserted through the scrotal wound grasp the gubernaculum and pull the testicle in place. Inset *A* shows interrupted suture fixing tunica albuginea to fascia lata. Some surgeons, for fear of injuring the testicle, prefer to suture the gubernaculum to the fascia lata.

The testicle with its covering sac is lifted from its bed and gentle traction is made on the cord. This demonstrates the bands that prevent the descent of the testicle into the scrotum. These bands are usually connective tissue and can be cut with scissors or torn with forceps. The cord is so dissected that only the blood vessels and the vas are left and these are separated from the posterior layer of the peritoneum by blunt dissection as far as possible. In this way the cord is lengthened for several inches A thorough lengthening of the cord is an important step in the operation The finger is inserted into the scrotum and burrows a pocket for the testicle. This pocket is enlarged by pushing down closed pedicle forceps and spreading the blades The testicle is inserted into this pocket and is held by a purse-string suture passed through the pillows of the external inguinal ring but tied lightly so as not to compress the circulation of the cord. The wound is closed by shoving the cord to the inner angle of the wound and uniting Poupart's ligament with the conjoined tendon over the cord.

Excision of the sac necessarily gives the largest number of cures of hydrocele, and if injections have not been successful, excision, particularly when the sac is large and thick, is the operation of choice. An incision is made through the anterior surface of the scrotum down to the hydrocele sac. The various coverings are separated until the sac is exposed but it is not opened. It is then bluntly dissected free from its surroundings as far as possible and delivered into the wound. Occasionally the hydrocele sac is of such a nature that it can be dissected free and removed without being opened. This, of course, is an anatomic peculiarity and does not often occur. After freeing as much of the sac as possible, it is opened and trimmed away close to the testicle, care being taken to leave no redundant fold The vessels are clamped and tied and the scrotal wound is closed with a continuous mattress suture which everts the edges of the skin wound and prevents the dartos muscle from pulling it in.

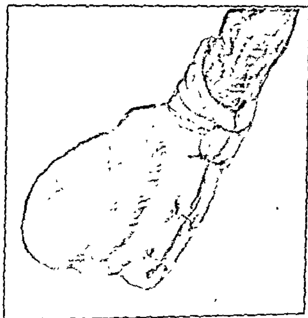


*Fig 1034*—Bottle operation for the cure of hydrocele. The sac is opened, everted, and sutured behind the testicle. If the portion of the wall of the large hydrocele is trimmed away, a neater result is obtained

## VARICOCELE

Varicose veins of the spermatic cord often occur in adolescent boys and young men. They are most frequently seen by the physician because the patient notices an unnatural condition or because he imagines or fears some disturbance of the sexual function.

At times the patient complains of a heavy dragging sensation or pain in the testicle or cord. Usually reassurance, sexual hygiene, and the application of a well-fitting suspensory bandage will correct the trouble. In cases with persistent pain or excessive enlargement of the veins with redundant scrotum, operation is indicated Operation should not be expected to relieve neurotic manifestations, which at times are made worse.

Neuralgia of the testicle may be accompanied by varicocele, and while the varicose veins, if excessive, should be removed, the neuralgic pain will not always be

relieved. Certain industrial organizations and the military service require excision of varicose veins of the cord before the individual may be employed or enlisted.

Most authors advocate exposure of the spermatic cord through an incision beginning just above the external inguinal ring and extending on to the upper portion of the scrotum. The veins are less tortuous in this area and those to be excised may be isolated more easily. However, the cord must be pulled upward and the more tortuous area exposed for ligation below; this appears to traumatize the cord.

A preferable incision is through the less vascular median raphe from the penis downward, or excision of a portion of the redundant scrotum. In either case the cord is easily exposed from the upper part of the scrotum to the testicle. The fascial coverings are incised and all bleeding points are ligated. The fascia covering the cord should not be separated by blunt dissection. Small torn blood vessels may be temporarily occluded by torsion and healing may be delayed by secondary bleeding. The redundant scrotum when not too excessive will gradually contract after the testicle is held up by ligation of the tortuous vessels and shortening of the cord. This process is very slow, and, in cases where the scrotum is greatly enlarged, excision of the excess gives the patient immediate impression of support, which is very helpful especially in the neurotic type of individual.

If the scrotum is to be resected, it is caught with an Allis forceps in the median raphe at about the junction of its upper and middle thirds and also at the junction of its middle and posterior thirds. The scrotum is lifted up and the redundant portion is clamped with pedicle forceps. This part is cut away with scissors while tension is made upon it The incision is just on the proximal side of the forceps, so the tissues that are injured by the clamp are excised. The bleeding vessels are quickly caught with hemostats. Every bleeding point must be clamped. After complete hemostasis has been secured with the clamps, the vessels are tied with fine plain catgut. The varicose veins over the cord are exposed by incision of the fascia along the cord, and the vas deferens, together with the spermatic artery, is freely delivered into the wound The spermatic artery is identified if possible. If this can be done, the spermatic artery, with one or two veins, and the vas deferens are gently isolated and separated from the rest of the dilated veins, but if it is impossible, the largest varicose veins are freed and about 5 cm. are removed after double ligation of the upper and lower portions of the veins with catgut. If the spermatic artery can be recognized and isolated along with the vas deferens and a few veins, the other veins may be safely removed after being ligated with catgut close to the testicle below and at the upper portion of the scrotum It is best to put two ligatures on each end to avoid the possibility of the ligature's slipping. The ends of one set of ligatures on each stump are left long. After the intervening segment of veins are incised, the stumps are tied together by the long ends of the ligatures

When in doubt it is much better to take out too few veins than too many. The shortening of the cord produced by removing a segment of veins and approximating the stumps and resection of the redundant portion of the scrotum when necessary will give such support to the testicle and structures of the cord that extreme radical procedures in removal of veins of the cord are not necessary. It is highly important to leave the spermatic artery, for, as has already been mentioned, complete atrophy of the parenchyma of the testicle is apt to occur after ligation of the spermatic artery After all bleeding points have been carefully secured and tied with fine plain catgut, the wound is closed with a continuous mattress suture of

chromic catgut. The suture is applied in the line of incision. A second row of sutures uniting the edges of the skin may be placed to secure more accurate apposition. Such a wound makes a scar that resembles very closely the median raphe, and, if the incision has been properly made, there are no teats or irritating protuberances that often follow a transverse incision for removing the redundant scrotum. This excellent technic for resection of the scrotum was developed by Stuart McGuire many years ago.

## Inguinal Varicocelectomy

Ivanissevich advised high ligation of the internal spermatic vein for the surgical treatment of varicoceles. Many other surgeons have reported favorable results with this operation.

An incision 6 cm. long is made over the course of the inguinal canal, with the distal extremity of the incision being over the external inguinal ring. This incision is carried through the skin and subcutaneous tissue down to the aponeurosis of the external oblique. Bleeders are clamped and tied with 0 plain catgut. The aponeurosis of the external oblique is then opened in the direction of its fibers, and the spermatic cord is isolated and picked up. The sheath of the cord is opened in its long axis. Most of the veins of the spermatic cord are isolated, leaving two or three veins posteriorly, along with the vas deferens and the spermatic artery. These excess veins, which are not as dilated as those in the scrotum, are then stripped free for a distance of about 4 cm., doubly ligated and resected. The proximal and distal stumps are tied together with the ligatures, the ends of two of the ligatures being left long. The incision in the sheath of the cord is approximated with 0 plain catgut in a transverse manner as against the vertical incision The two ligatures left long at the approximation of the stumps of the cord are threaded on a round needle and passed through the lower edge of the internal oblique muscle near the internal ring, emerging about 1 cm. apart, and are tied so as to form a mattress suture which serves to shorten the cord and elevates the testis about 2 cm Any hernia present is corrected by the method indicated; otherwise, the aponeurosis of the external oblique is closed with a continuous suture of 0 chromic catgut. Adequate patency of the external inguinal ring is assured, the subcutaneous tissues are approximated with a few interrupted sutures of 0 plain catgut, and the skin is closed with interrupted sutures of fine silk.

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# CHAPTER 74

# THE PENIS

Austin I. Dodson

External urethrotomy for deep strictures has already been described. Internal urethrotomy is but seldom practiced. Occasionally, however, there may be a marked decided narrowing of the external meatus which it is necessary to split This is done under local anesthesia by injecting the tissues around the meatus and incising the meatus at its lowest point.

## CIRCUMCISION

Circumcision may be done under local anesthesia. If on an infant, the adhesions that are often found between the glans penis and the prepuce should be well separated. By cutting down the prepuce without first separating these adhesions anteriorly, the meatus may be split and the glans injured, which will be followed by considerable bleeding. The prepuce is grasped anteriorly on each side of the midline by two small hemostats Slight traction is made, and if there is any reason to expect adhesions between the glans and the prepuce, a pair of curved scissors is inserted within the prepuce and gently spread so as to separate the adhesions sufficiently to make a dorsal incision in the prepuce without injuring the glans. A straight incision is then carried down the dorsum of the prepuce to a point opposite the corona (Fig. 1035, *A*). This point must be determined before too much traction is made upon the prepuce, as otherwise the incision may be carried too far. Any further adhesions are now thoroughly separated and the prepuce is trimmed from the upper end of this dorsal incision around to the frenum on each side parallel with the corona. Sufficient tissue should be left at the frenum to allow for suturing without contraction The bleeding points are caught with mosquito forceps and tied with fine catgut. The wound is closed with a continuous suture of fine chromic catgut which begins on the right of the frenum, is carried around the incision and terminates a short distance from its beginning (Fig. 1035, *B*). This leaves a slight interval between the beginning and the end of the suture, which allows for swelling or erection. If the tissues of the frenum are not satisfactorily covered by this suture, one or two interrupted sutures of fine catgut are placed.

A method in use at the outpatient department of the Medical College of Virginia is preferable for beginners and when no assistance is available. With the penis lying naturally, and with no tension on the prepuce, an incision is made with a sharp knife following the prominence of the corona (Fig. 1036) The prepuce is then retracted and a similar incision is made in the mucous membrane about 0.5 cm behind the corona, except at the frenum where a little more margin is allowed. The skin

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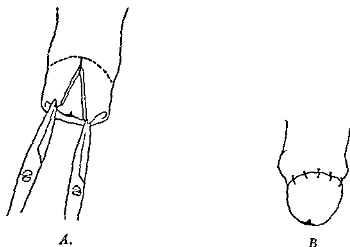



Fig. 1035.—*A*, The first stage of circumcision. The dorsal incision is made and the dotted line shows the incision for removal of the prepuce, which should be just distal to the corona. *B*, The circumcision is completed

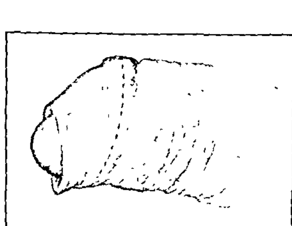


Fig. 1036.

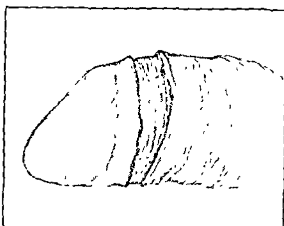


Fig. 1037

Fig 1036—An incision is made with a sharp knife through the skin and superficial fascia over the prominence of the corona. *After the incision in the skin has been made, the* prepuce is retracted and a similar incision is made through *the* mucous membrane about 0 5 cm behind the corona.

Fig 1037—In this illustration both incisions have been made and the intervening tissue excised

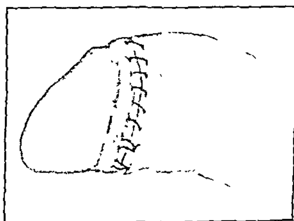


Fig 1038—After ligating the bleeding vessels, the wound is closed with a continuous suture of fine chromic catgut It is a good idea to use two sutures, leaving a short intervening space which prevents constriction in case of swelling

and mucous membrane beyond the two incisions are cut away with scissors (Fig. 1037), hemostasis is secured, and the wound is closed as previously described (Fig. 1038). This method assures smooth incisions which fit together accurately, and there is no danger of removing too much tissue.

## EPISPADIAS

The surgical requirements in the treatment of epispadias vary according to the extent of the deformity. In the incomplete cases operations are required to repair the defect and correct the malposition of the urethra and the deformity of the penis. In complete epispadias it is also necessary to reconstruct the sphincters of the bladder or, failing in this, to transplant the ureters into the sigmoid.

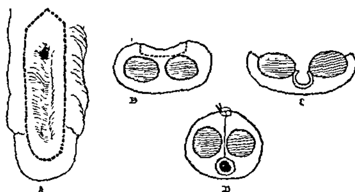



Fig. 1039.—The operation of Cantwell for epispadias *A* shows the epispadias, with the dotted line indicating the i[illegible] skin flap which is to form [illegible] in *epispadias*. *C*, The fl[illegible] which are easily separated [illegible] *D*, Cross section representing the operation completed.

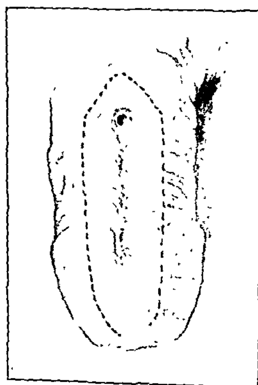


Fig. 1040.—Epispadias. The penis is broad and thin. A groove extends from the urethral orifice to the end of the penis.

In the simpler forms the operation of Cantwell is probably the most satisfactory. This method depends upon the fact that in this disease the two corpora cavernosa are much more loosely attached to each other than in a normal penis and can be readily separated. The first step in this as in any plastic operation on the penis is to provide for drainage of the bladder, either through the perineum or suprapubically, in order to divert the stream of urine while the wound in the penis is healing.

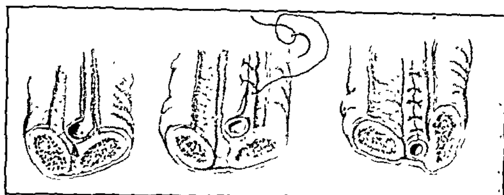


Fig. 1041. Fig. 1042. Fig. 1043.

Fig. 1041.—Young's operation for the cure of epispadias. The flap is dissected chiefly from one corpus cavernosum, leaving it attached to the opposite one by a broad base.

Fig. 1042.—The corpora have been separated and the flap is sutured over a small catheter.

Fig. 1043.—The corpus to which the newly formed urethra is attached is rotated inward, carrying the urethra near the ventral surface of the penis.

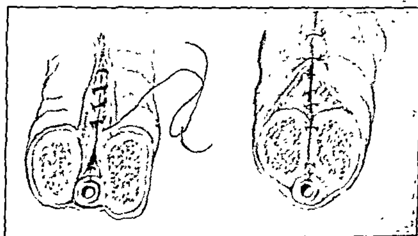


Fig 1044. Fig. 1045.

Fig. 1044.—The urethra in place, the corpora are sutured together with 0 chromic catgut

Fig. 1045.—Showing suture of Buck's fascia and closure of the skin

The perineal operation is best here and can be quickly done by a short incision through the perineum on a sound in the urethra On each side of the groove of the epispadias that represents the urethra an incision is made along the junction of the mucosa and the skin extending from the symphysis to the extremity of the glans. These incisions extend down to the corpora cavernosa but not into them. The urethra is freed as a flap from its bed and held up while the two corpora cavernosa are separated from each other until the skin on the lower surface of the penis is reached.

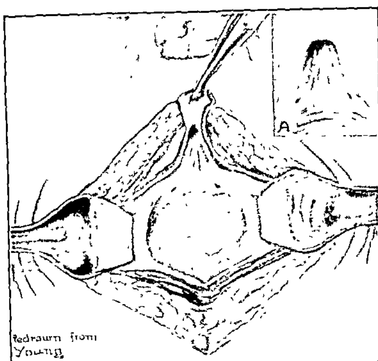



Fig 1046—Young's operation for the cure of incontinence associated with epispadias. The bladder is widely opened and a triangular section is removed from the anterior portion of the prostatic urethra.

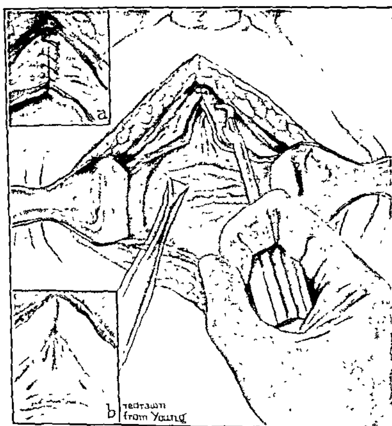



Fig 1047.—Operation for cure of epispadias, prostatic urethra being closed. The closure after the method of Young leaves a normal internal vesical orifice.

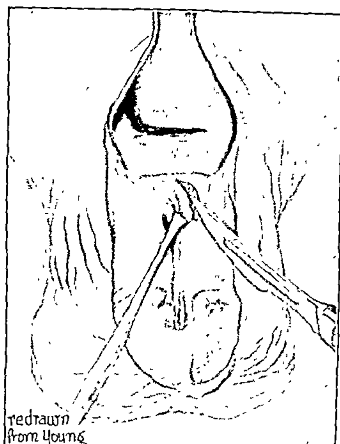



Fig. 1048 —Operation for cure of epispadias The roof of the membranous urethra is being excised through the epispadiac opening.

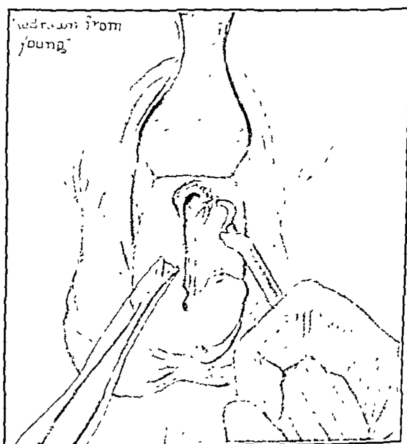



Fig. 1049 —Operation for cure of epispadias. Suturing the roof of the membranous urethra to tighten the external sphincter

The mobilized urethra is now placed in the bottom of this wound and fixed by sutures. A sound is laid in the urethra and the skin of the urethra is sutured over it. The corpora cavernosa are brought together by a few sutures and the skin is closed over them in the usual manner. The illustrations show the steps of the operation (Fig. 1039). The base of the flap of the urethra is at the root of the penis so that there should be no trouble about the nutrition of this transplanted mucosa of the urethra.

The operation of Young is similar to Cantwell's operation except that he leaves the flap for construction of the urethra attached for its entire length to one of the corpora cavernosa and, after freeing the corpora, rotates this body mesially to bring the urethra to its normal position (Figs. 1040-1045).

In cases of complete epispadias, it is necessary to repair the defects in the sphincters of the bladder. A method for successfully repairing the sphincters was published by Young in 1922. The bladder is opened suprapubically and a section is removed from the superior part of the bladder orifice extending down through the prostatic urethra. In complete epispadias the vesicle sphincter is lacking in this area. The dissection is carried down onto the sides of the bladder neck until thick muscle bundles are reached. The roof of the prostatic urethra and of the bladder orifice is then closed, including the muscle which is sutured together in the midline. In this way the bladder orifice is reduced to a normal state. The wound in the bladder is closed, leaving a suprapubic tube for drainage. The external sphincter is repaired from below. The mucous membrane from the roof of the membranous urethra is dissected off to the prostatic urethra, and sutures are placed to constrict the lumen of this portion of the urethra, bringing together in the midline above the more developed portions of the external sphincter (Figs. 1046-1049).

## HYPOSPADIAS

The first step in the correction of hypospadias is straightening the penis. This is done by making a transverse incision on the undersurface of the penis just behind the glans. The incision should divide Buck's fascia and all constricting fibers of the intracavernous septum. The incision is sutured longitudinally. This preliminary operation should be done early in life so that the corpora cavernosa may develop normally. We have found it helpful to keep the penis straight while it is healing by suturing the glans to the skin of the lower abodmen by a single silk suture.

The urine must be diverted from the field of operation either by perineal urethrostomy or suprapubic cystostomy. In perineal hypospadias the hypospadiac opening serves for drainage until the urethra has been constructed to within about 1 75 cm. of the opening. Then a suprapubic cystostomy is done for drainage after the perineal defect is closed. When the urethra opens anterior to the perineum, a perineal urethrostomy is the best method of drainage. When the operation is to be done in stages, a permanent urethrostomy may be made by extending the incision in the urethra for about 1.75 cm. and suturing the mucous membrane to the skin. This is not difficult in children where the urethra is near the surface. With this procedure it is not necessary to keep a catheter in place until the wound has healed; consequently, there is less danger of infection of the urinary tract, and a repeated urethrostomy is avoided. The fistula is easily closed by separating the mucous membrane from the skin and suturing the opening with interrupted sutures of silk.

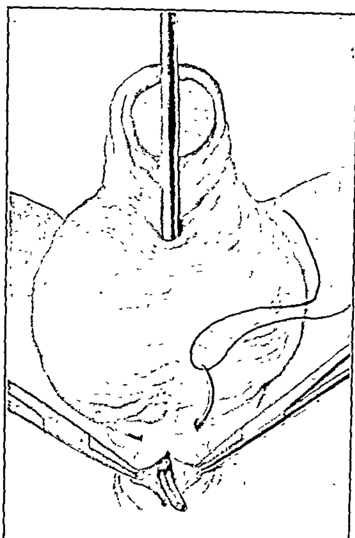


Fig 1050—A suture is being placed around the urethra to prevent urine from entering the anterior urethra until the wound is healed. The suture is tied just tightly enough to occlude the urethra.

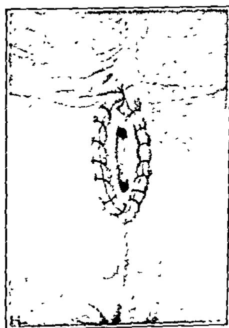


Fig 1051—External urethrotomy with the mucous membrane of the urethra sutured to the skin to prevent closing When the deformity has been corrected, the mucous membrane is separated and the wound is closed.

Plastic operations for the correction of hypospadias often fail because the principles underlying all plastic surgery are neglected. Absolute asepsis during the operation is essential. In addition to cleansing the skin thoroughly, the hypospadiac urethra, a frequent source of infection, must be kept clean. The premature passage of urine through the newly formed urethra, caused by blockage of the perineal drainage tube, is a frequent cause of infection and breaking down of the sutures. This may be prevented by placing a silk suture around the urethra just in front of the urethrotomy and tying it just tightly enough to occlude but not cut through the urethra (Figs. 1050 and 1051).

Another frequent cause of failure in incomplete hemostasis. Wherever there is the slightest bleeding, the points must be ligated. In no instance should one trust to the placing of sutures or pressure to control minute bleeding points. Wherever blood clots form, sinuses are apt to occur.

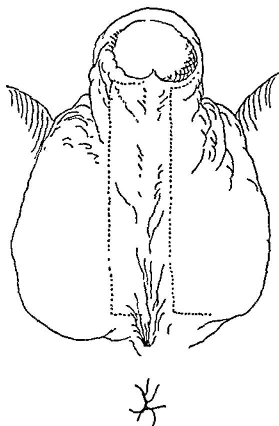


Fig. 1052.—Outline of skin flaps for the cure of perineal hypospadias by the Thiersch method The perineal *opening* is left for drainage until the anterior urethra has been constructed

In outlining flaps and grafts, it is important to remember that the skin of the penis and scrotum shrinks considerably when dissected free. Efforts to construct and to cover the urethra with inadequate skin flaps result in excessive tension on the sutures and interference with the blood supply along the line of sutures, followed by slough and complete failure or by the formation of fistulas. An adequate blood supply is most important. A broad pedicle should be left for the nourishment of flaps which should be dissected just far enough to permit accurate approximation without tension. The least complicated operations are more apt to be successful. The flap should have a broad base and should be constructed from the skin of the penis it-

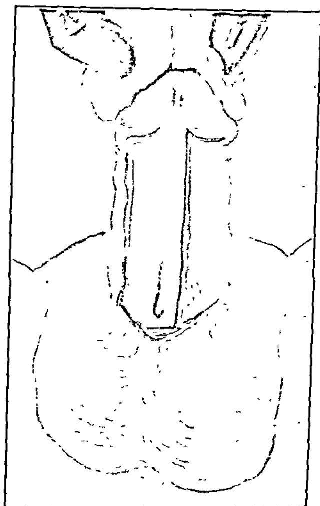


Fig. 1053.—The outline of flaps for construction of the anterior urethra by the Thiersch method.

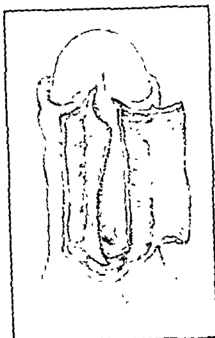


Fig 1054.

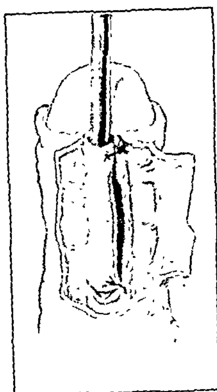


Fig. 1055.

Fig. 1054.—The flaps are dissected up, leaving a broad base attached to preserve the blood supply.

Fig. 1055.—The largest side of the central skin flap is sutured over a catheter to the opposite side which has been dissected just far enough for accurate suturing.

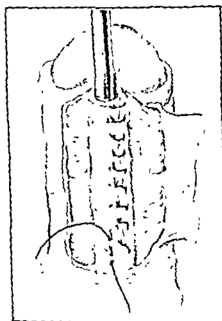


Fig. 1056

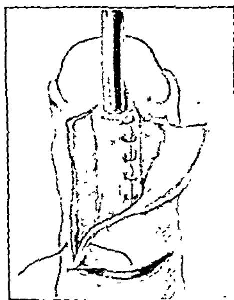


Fig. 1057.

Fig 1056.—The new urethra completed by a continuous suture of 000 chromic catgut. The skin margin is turned into the urethra

Fig. 1057.—The lateral flap is brought over the urethra and sutured to the skin margin on the opposite side.

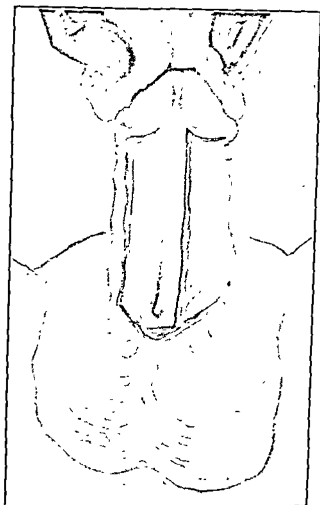
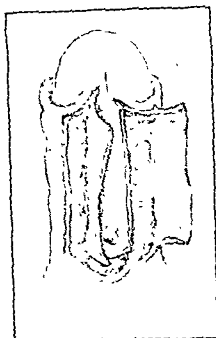


Fig. 1053.—The outline of flaps for construction of the anterior urethra by the Thiersch method.



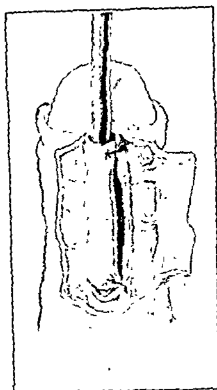
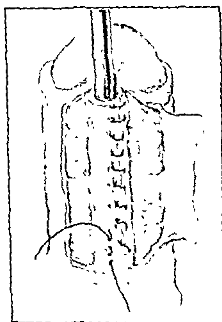


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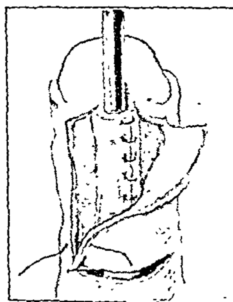


Fig. 1056 Fig. 1057.

Fig. 1056.—The new urethra completed by a continuous suture of 000 chromic catg The skin margin is turned into the urethra.

Fig. 1057.—The lateral flap is brought over the urethra and sutured to the skin marg on the opposite side.

self when it is possible. If the roof of the urethra is left attached along the surface of the penis, there is no doubt that the canal will develop with the development of the penis.

These principles are embodied in the Thiersch method of reconstructing the urethra. Flaps for forming the urethra are outlined along the ventral surface of the penis by parallel incisions about 1.75 cm apart, beginning at the base of the glans and extending just posterior to the hypospadiac opening, and these incisions are joined posteriorly by a transverse incision (Figs 1052 and 1053). One of the longitudinal incisions is located nearer the midline than the other, and the skin used to form the ventral surface and lateral walls of the urethra is dissected from the side of the broadest flap; on the other side the skin is dissected just far enough to be readily sutured to the other flap (Fig. 1054). The roof of the newly formed urethra forms the base of the pedicle. The flaps are so sutured with interrupted or continuous sutures of 000 chromic catgut that the skin margins will be turned into a newly formed urethra (Figs. 1055 and 1056). The flap for covering the urethra is taken

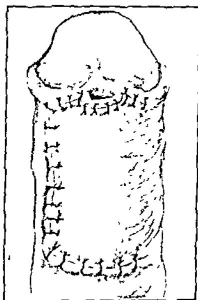


Fig 1058 —The completed operation.

from the side of the penis opposite the site of the larger flap and when brought across and sutured, broad flat surfaces are approximated and the lines of sutures are not opposite each other (Figs. 1057 and 1058). In this way fistulas are less likely to occur. Suturing of the transverse incision posterior to the hypospadias opening completes the operation. The urethra may be carried through the glans at a later operation by utilizing a tube constructed from the prepuce This is not necessary, however, since the meatus at the base of the glans functions quite satisfactorily.

The operation of Bidder is useful when the opening is at the penoscrotal area and when there is not sufficient skin on the penis to construct a satisfactory urethra. Parallel incisions are made on the ventral surface of the penis extending from the glans penis to the penoscrotal junction and for an equal distance on the scrotum (Fig. 1059). The margins of the flaps are dissected up a very short distance, and beginning at the penoscrotal junction the margins of the flap outlined on the ventral surface of the penis are sutured to those of the flap outlined on the scrotum so that the roof of the new urethra is formed by the skin of the penis and the floor by that

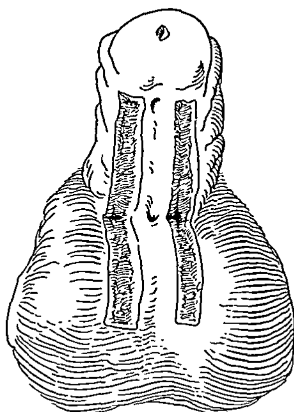


Fig. 1059.—The operation of Bidder for the cure of hypospadias. Parallel incisions are made on the ventral surface of the penis and extending an equal distance on the scrotum.

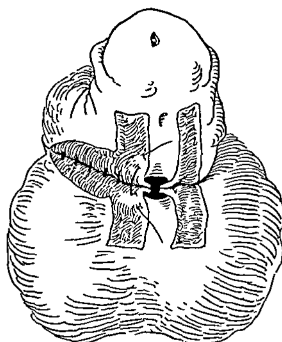


Fig 1060.—The ventral surface of the penis is approximated to the anterior surface of the scrotum and the flap outlined on the penis is sutured to that of the scrotum, forming a urethra to the end of the penis.

of the scrotum. The edges of the skin are turned into the urethra (Fig. 1060). The outer edges of the wound are then closed *with interrupted* mattress sutures (Fig. 1061). When the wound has entirely healed, the penis is dissected from the scrotum, carrying with it the reconstructed urethra (Figs. 1062 *and 1063*). *The* wound in the penis and scrotum is closed in a straight line by interrupted or continuous sutures of chromic catgut or silk (*Fig.* 1064).

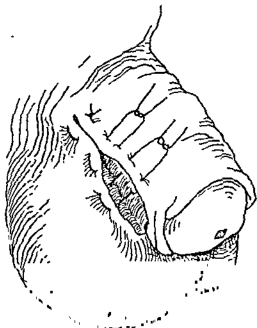


Fig 1061.—The external skin margin of the penis is likewise sutured to that of the scrotum

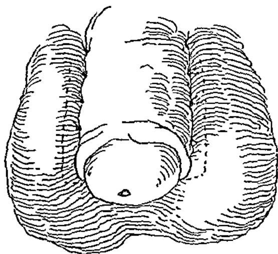


Fig 1062 —Line of incision for dissecting flaps from the scrotum after healing has occurred.

The disadvantage of this operation is that urinary salts may collect on hairs growing from the scrotal portion of the flap and form urethral calculi This disadvantage is overcome by Cecil's modification of the Bucknall operation in which the urethra is formed from the skin of the penis by dissecting up longitudinal flaps to form a tube. A longitudinal incision is then made in the scrotum and the newly formed urethra is buried in the scrotum by suturing the margins of the scrotal incision to the skin of the penis as in the Bucknall operation (Fig. 1065). When the wound is healed, the penis is dissected from the scrotum and the operation completed as in the original Bucknall operation.

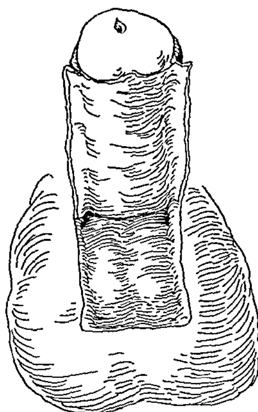


Fig. 1063.—Dissection of skin flaps containing newly formed urethra from the scrotum.

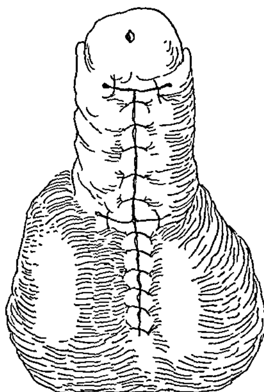


Fig. 1064.—The wound on penis and scrotum is closed by a continuous line of fine chromic catgut sutures

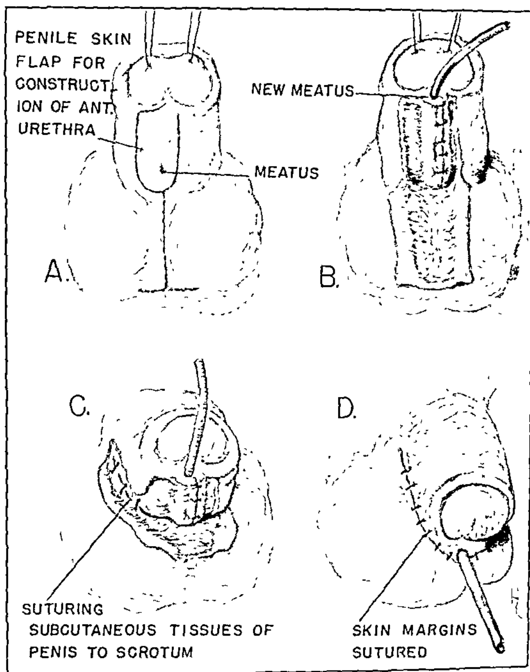



Fig 1065.—Cecil's modification of the Bucknall operation. The urethra is constructed from skin of the penis and buried in the scrotum. The penis is later dissected from the scrotum and the operation is completed as in the original Bucknall operation

## AMPUTATION OF THE PENIS

Amputation of the penis is rarely necessary except for cancer and should vary according to the extent of the growth and the age and physical condition of the patient. It is unnecessary to remove an extensive portion of the penis when the cancer is limited to the distal portion. A margin of 1.5 cm. posterior to the proximal limit of the growth insures freedom from recurrence in the stump. It must be remembered, however, that if the stump is so short that it retracts beneath the skin of the scrotum, the maintenance of personal hygiene will be more difficult than if the entire penis is removed and the urethral orifice established in the perineum.

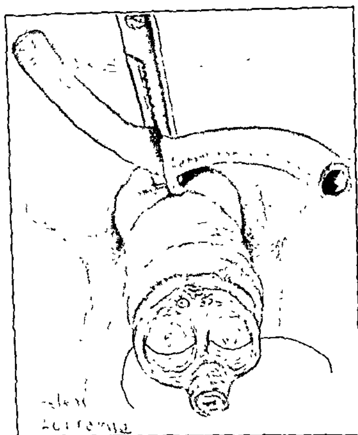


Fig 1066—Roger Graves' technic of partial amputation of the penis. The corporus spongiosum and urethra are left a little longer than the corpora cavernosa. After Buck's fascia is approximated, the skin is closed and the urethra is split and sutured to the skin near the lower end of the incision.

The operative technic devised by Graves is quite satisfactory. A conservative or radical amputation of the penis is done, depending upon the extent of the cancer, and the regional lymph nodes are removed at the same time or at a later operation by two curved incisions designed to expose the glands probably involved without extensive undermining of skin margins. There is less immediate shock to the patient and less probability of sloughing and suppuration of the wound.

Conservative (Partial) Amputation of the Penis.—The most important requirements in partial amputation are that an adequate length of healthy tissue be removed with the cancer to insure against recurrence in the stump and that the urethra be left a little longer than the corpora cavernosa to permit satisfactory urination and prevent stenosis of the meatus. After application of a tourniquet at the base

of the penis, an incision is made through the skin completely around the penis and about 2 cm. from the apparent border of the disease. The skin after being divided is retracted and the dorsal vein and artery are exposed, ligated, and divided. The corpora cavernosa are divided transversely and the corpus spongiosum and urethra are divided about 1 cm. in front of the stump of the corpora cavernosa. The ends of the corpora cavernosa are closed with interrupted sutures of 0 chromic catgut, each suture passing from the margin of Buck's fascia on one side of the stump to an opposite point on the other. Each suture should take a bite in the septum between the corpora. In this way bleeding is entirely controlled (Fig. 1066). The urethra is split a short distance and each flap is sutured to the adjacent skin margin of the stump. Above the urethra the skin is sutured over the ends of the corpora cavernosa with interrupted sutures of coarse silk or cotton. The wound may be protected by the application of compound tincture of benzoin. No dressing is necessary. If a liberal portion of the penis has been left, a retained catheter is unnecessary.

**Complete Amputaton.**—The following method advocated by Graves is the most satisfactory one for removing the entire penis. A vertical midline suprapubic incision is made, extending from the base of the penis upward. It should be extended so that the scrotum will be pulled away from the perineum when it is sutured to the apex of the wound at the close of the operation. The lower end of the incision encircles the penis and penetrates to the investing fascia of the corpora cavernosa and spongiosum. The fat beneath the suprapubic incision, lying between the medial aspects of the spermatic cord and around the base of the penis, is dissected away, down to the deep fascia to be removed with the penis (Fig. 1067). The corpus spongiosum and urethra are now cut across, preferably with a high frequency knife, proximal to the diseased process, leaving sufficient length of urethra to be transplanted without tension into the perineum. The corpus spongiosum is dissected from the corpora cavernosa from the point of division downward and backward until it can be brought though a stab wound in the perineum between the anus and base of the scrotum without angulation or tension. The scrotal tissues are easily separated from the penis by blunt dissection, and division of the scrotum is not necessary. Care is necessary in separating the corpus spongiosum from the corpora cavernosa, as there is no ready line of cleavage until the region of the bulb is approached. Sharp dissection is necessary to prevent injury to the urethra and is aided by passing a soft bougie or catheter into the urethra. When the urethra has been completely freed from the corpora cavernosa, it is brought directly through a stab wound in the perineum and fixed to the skin by subcuticular sutures of fine chromic catgut, one on each side and one posteriorly. The redundant portion of the urethra is excised about 1 cm from the skin, and a small rubber tissue drain is brought through the stab wound anterior to the urethra. The corpora cavernosa are dissected free by first dividing the suspensory ligament and ligating and dividing the dorsal artery and vein at the base of the penis. The dissection is continued toward the roots of the penis, keeping close to the investing fascia. When the roots of the cavernous bodies are reached, the bulbous urethra is protected by a wooden spatula covered with moist gauze while the cavernous bodies are amputated near their attachments with a mildly coagulating current. The exposed ends of the stumps are closed with continuous sutures of No 1 plain catgut It is not necessary to remove the corpora down to their attachments to the ischiopubic rami. The upper portion of the

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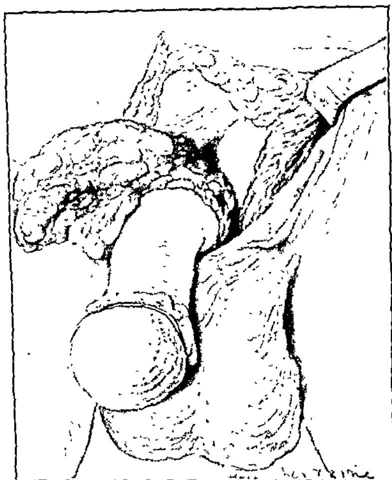


Fig 1067.—Roger Graves' operation for radical amputation of the penis. Fat and fascia dissected from the pubic area and suspensory ligament divided, freeing the penis from attachments to the pubis. The urethra is divided at a safe area proximal to the tumor, dissected free, and transplanted to the perineum.

## BLOCK DISSECTION OF INGUINAL AND FEMORAL AREAS

The inguinal glands may be dissected following either the conservative or radical amputation, at the same time or later, depending upon the judgment of the operator. The extent of the dissection should be determined by the nature of the lesion and the physical condition of the patient. Since the superficial glands communicate efferently with the deep inguinal and external iliac nodes, the dissection should be as complete as circumstances will permit. The dissection described may be terminated at any stage. It is applicable to gland dissection necessary because

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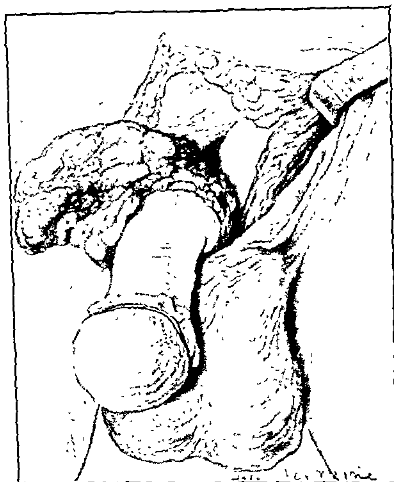


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**Complete Amputaton.**—The following method advocated by Graves is the most satisfactory one for removing the entire penis. A vertical midline suprapubic incision is made, extending from the base of the penis upward. It should be extended so that the scrotum will be pulled away from the perineum when it is sutured to the apex of the wound at the close of the operation. The lower end of the incision encircles the penis and penetrates to the investing fascia of the corpora cavernosa and spongiosum The fat beneath the suprapubic incision, lying between the medial aspects of the spermatic cord and around the base of the penis, is dissected away, down to the deep fascia to be removed with the penis (Fig. 1067). The corpus spongiosum and urethra are now cut across, preferably with a high frequency knife, proximal to the diseased process, leaving sufficient length of urethra to be transplanted without tension into the perineum. The corpus spongiosum is dissected from the corpora cavernosa from the point of division downward and backward until it can be brought though a stab wound in the perineum between the anus and base of the scrotum without angulation or tension. The scrotal tissues are easily separated from the penis by blunt dissection, and division of the scrotum is not necessary. Care is necessary in separating the corpus spongiosum from the corpora cavernosa, as there is no ready line of cleavage until the region of the bulb is approached. Sharp dissection is necessary to prevent injury to the urethra and is aided by passing a soft bougie or catheter into the urethra. When the urethra has been completely freed from the corpora cavernosa, it is brought directly through a stab wound in the perineum and fixed to the skin by subcuticular sutures of fine chromic catgut, one on each side and one posteriorly. The redundant portion of the urethra is excised about 1 cm. from the skin, and a small rubber tissue drain is brought through the stab wound anterior to the urethra. The corpora cavernosa are dissected free by first dividing the suspensory ligament and ligating and dividing the dorsal artery and vein at the base of the penis The dissection is continued toward the roots of the penis, keeping close to the investing fascia. When the roots of the cavernous bodies are reached, the bulbous urethra is protected by a wooden spatula covered with moist gauze while the cavernous bodies are amputated near their attachments with a mildly coagulating current. The exposed ends of the stumps are closed with continuous sutures of No 1 plain catgut It is not necessary to remove the corpora down to their attachments to the ischiopubic rami. The upper portion of the

scrotum is now sutured to the margins of the suprapubic wound by two rows of sutures, subcuticular sutures of plain catgut in the fat and fascia, and coarse silk or cotton in the skin. The first suture approximates the raphe of the scrotum to the upper angle of the suprapubic wound. Small wicks of rubber-covered gauze are placed in the lower angles of the wound for temporary drainage. A small soft catheter is passed into the bladder and fastened to the upper portion of the thigh with adhesive for drainage. This catheter is left in place for the first few days. A gauze pad is placed against the perineum in front of the urethra and is held firmly in place by a perineal binder. This elevates the scrotum and obliterates the newly opened space back of the scrotum.

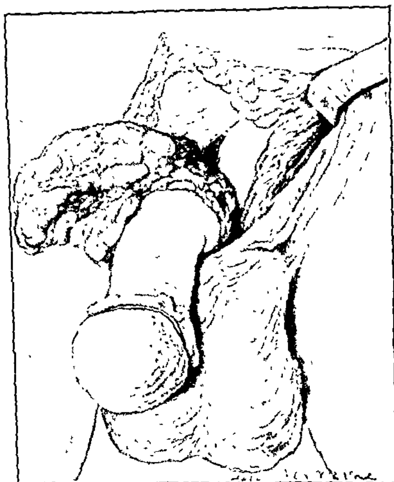


Fig 1067.—Roger Graves' operation for radical amputation of the penis Fat and fascia dissected from the pubic area and suspensory ligament divided, freeing the penis from attachments to the pubis. The urethra is divided at a safe area proximal to the tumor, dissected free, and transplanted to the perineum.

## BLOCK DISSECTION OF INGUINAL AND FEMORAL AREAS

The inguinal glands may be dissected following either the conservative or radical amputation, at the same time or later, depending upon the judgment of the operator. The extent of the dissection should be determined by the nature of the lesion and the physical condition of the patient. Since the superficial glands communicate efferently with the deep inguinal and external iliac nodes, the dissection should be as complete as circumstances will permit. The dissection described may be terminated at any stage. It is applicable to gland dissection necessary because

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mass of tissue to be removed. The underlying femoral vessels and the muscles of the thigh in the femoral triangle are exposed. During this part of the operation much time is saved if the assistant dissects on one side while the operator dissects on the other.

The second step in the dissection consists of removing the femoral sheath with its contained adipose tissue and glands from the femoral vessels throughout the extent of the femoral triangle. The surrounding fibrous and adipose tissue should be removed from the femoral vessels, their circumflex and deep branches, and the femoral nerve (Fig. 1069). When necessary, small ramifying vessels may be ligated and divided to facilitate the dissection.

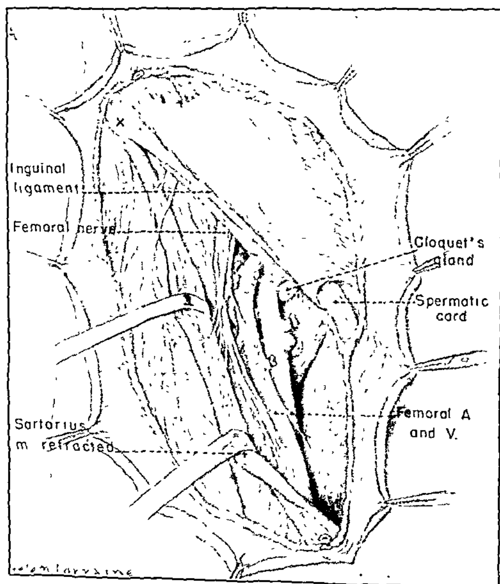



Fig 1069.—The femoral sheath with its adipose tissue and glands have been removed

The third and final stage of the dissection consists of removing lymph glands, areolar tissue and fat located along the iliac vessels. The iliac nodes are exposed by incising the aponeurosis of the external oblique muscle from the external ring to a point just above the internal ring. The external oblique fascia and transversalis muscle are incised lateral to the spermatic cord, exposing the properitoneal fat. All

of lesions of the lower extremities, the gluteal and anal regions, and external genitalia of the male or female. Dissections because of lesions of the anal area or external genitalia should always be bilateral. Each incision begins medial to the anterior superior spine of the ilium and extends parallel to and a little above Poupart's ligament to within one fingerbreadth of the pubic spine where it curves downward and outward across the area of the femoral triangle. More adequate exposure is afforded than when a simple oblique incision is used and the poorly healing corners of a T-shaped wound are avoided. Beginning at the upper angles of the

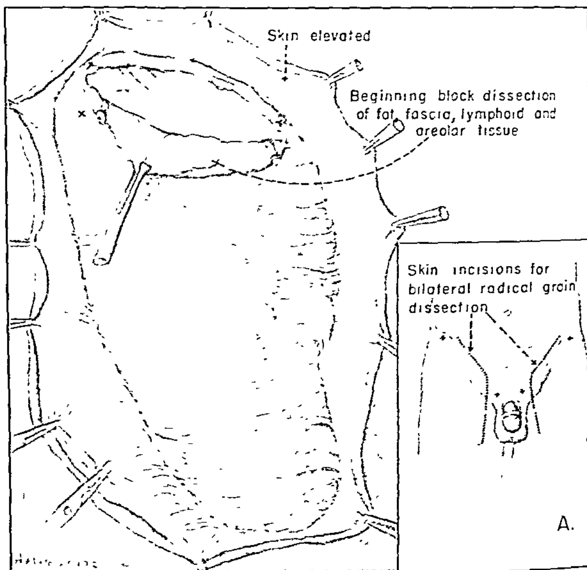



Fig 1068.—Block dissection for excision of glands from inguinal and femoral areas The margins of the wound are elevated, and the fascia, fat, and superficial glands are removed from above downward. Outline of incisions indicated in inset *A*.

wounds, the skin is elevated and the fat glands and fascia are dissected cleanly from the muscles or their aponeurosis from above downward (Fig. 1068). This dissection exposes the inguinal ligaments, the external rings, and the fascial coverings of the spermatic cords. The fat which accompanies the spermatic cords is removed for a short distance down the scrotal sac. The dissection is continued below Poupart's ligament, removing fat, fascia, and glands superficial to the femoral vessels. The saphenous artery and vein are ligated above and below the

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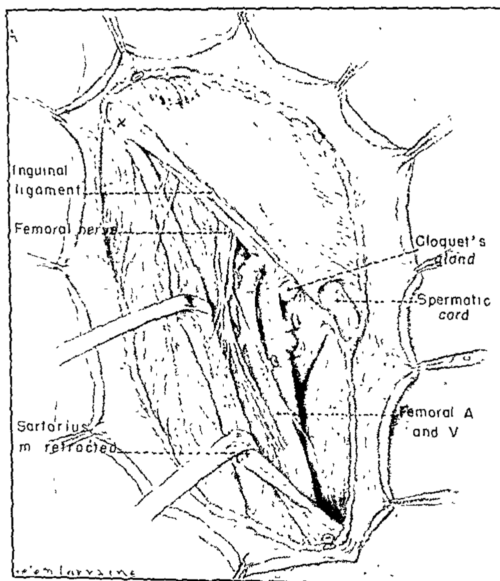



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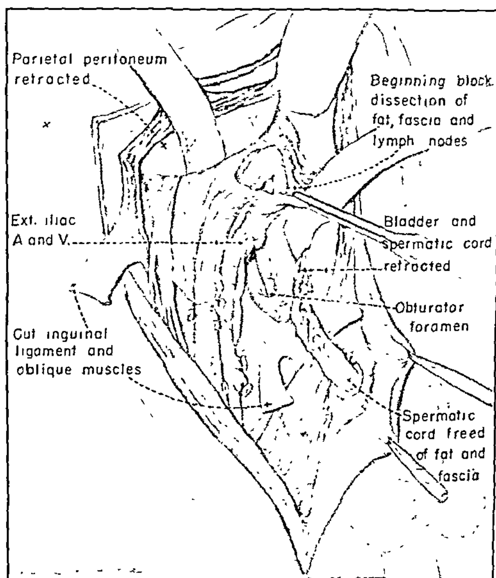



Fig. 1070.—Dissection of areolar tissue and glands from iliac area.

fat and fascia are dissected from the spermatic cord and it is retracted medially. The inguinal ligament and adjoining fascia are divided over the femoral vessels, thereby permitting easy access to areolar and glandular tissue in this area. The parietal peritoneum is then liberated and retracted upward and medially, exposing the iliac vessels from the point of bifurcation downward (Fig. 1070). It is usually necessary to ligate and divide the inferior epigastric vessels to obtain adequate exposure. All fat, fascia, and lymph nodes are cleanly removed from the bifurcation of the common iliac vessels downward, including glands situated around the obturator foramen. Following the dissection practically no fat or areolar tissue should be left in the operative field. After all bleeding has been carefully controlled the inguinal ligament is united over the femoral vessels and the inguinal canal reconstructed over the spermatic cord. Penrose drains are placed at both angles of the wound and the skin incision is closed carefully. A pressure dressing is applied.

## References


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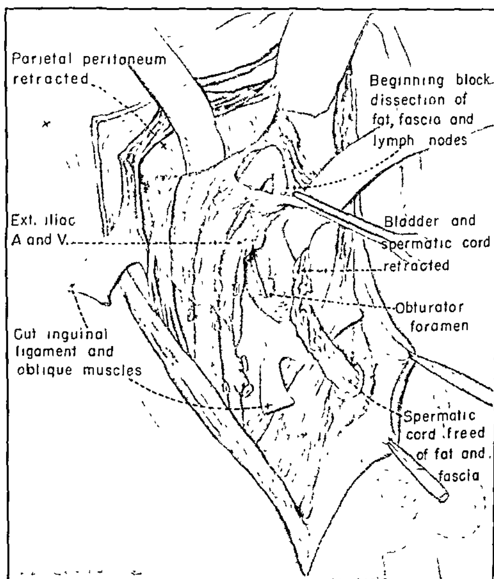



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# CHAPTER 75

# THE VULVA

RANDOLPH H. HOGE

There are many benign lesions of the vulva, some of them similar to ones occurring elsewhere on the skin and mucous membranes, which require simple excision or partial vulvectomy. Most of them present no special problem and will not be discussed in this section.

## OPERATIONS ON THE VULVOVAGINAL (BARTHOLIN) GLAND

This gland is commonly the site of abscess or cyst formation. Once infected, the gland is apt to be the site of recurrent trouble, and extirpation is usually indicated.

Formerly the surgical treatment of an abscess of this gland was incision and drainage. Now, since the advent of antibiotics, one has the choice of incision or excision In incision a vertical opening over the most superficial portion of the abscess is made with a sharp scalpel extending the diameter of the abscess. The pus is evacuated, smeared and cultured, and a rubber drain or gauze pack is inserted into the abscess cavity. Incision will give quick relief, but the relief is often temporary. Sooner or later in most cases excision will be necessary, so there is reason to excise the gland at the beginning. If excision is done in the presence of an active infection, the wound may be loosely sutured and a small rubber drain inserted. Preoperatively and postoperatively, in cases of infection, the patient is given appropriate antibiotics, and sitz baths may be used. The drain is removed within several days.

The treatment of a vulvovaginal gland cyst is excision (Fig. 1071). An incision through the mucous membrane of the vestibule is made over the cyst. This incision is on the medial side of the labium minus and is parallel to its long axis. It extends beyond the cyst anteriorly and posteriorly. If the cyst is large, the initial incision is elliptical so that a portion of mucosa is removed to prevent redundancy of tissue when the wound is closed (Fig 1072). The mucosal edges of the incision are caught with Allis clamps, one on each side and one at each angle, to act as tractors. The incision is carried down to the cyst wall and the cystic gland is dissected free (Fig 1073) This can usually be done in part by blunt dissection, using the knife handle or gauze, but at many points sharp dissection with the knife or scissors will be necessary. An attempt should be made to excise the structure without rupture, and this can usually be done. Furthermore, considerable care must be exercised to avoid buttonholing the medial flap of mucous membrane of the vestibule. The field is very vascular due in large part to the proximity of the bulb of the vestibule. Accordingly, many bleeding points will be encountered during the dissection and these should be clamped

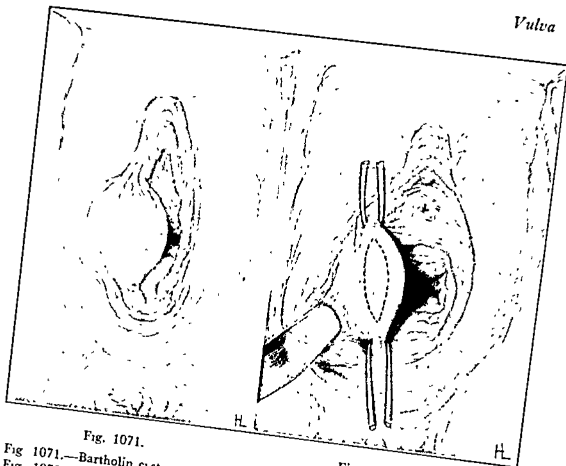



Fig 1071.—Bartholin cyst.

Fig 1072.—Excision of Bartholin cyst The mucosa of the vestibule above and below the cyst is caught with Allis clamps An elliptical incision is made along the broken line on the medial side of the labium minor, and the cystic gland is dissected from its bed.

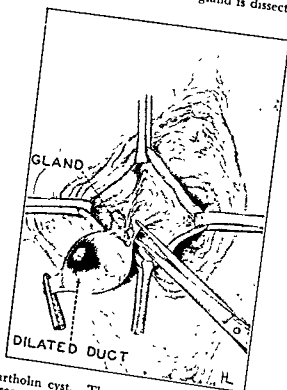



Fig 1073—Excision of Bartholin cyst. The wound is held open with Allis clamps, the cyst dissected free, and the glandular portion of the mass removed.

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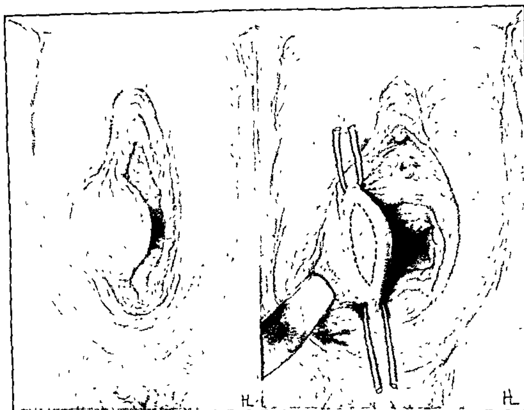
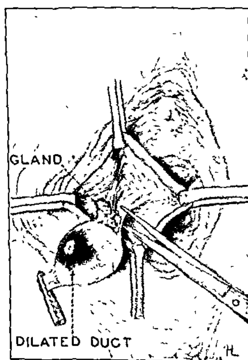


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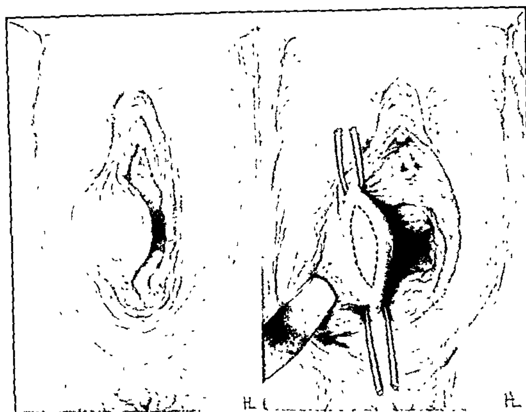


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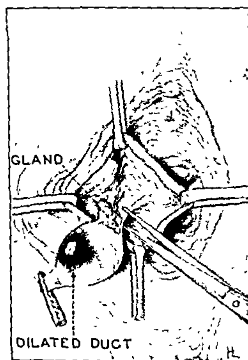



Fig 1073.—Excision of Bartholin cyst. The wound is held open with Allis clamps, the cyst dissected free, and the glandular portion of the mass removed.

result from too much tension in this area. The mucosal flap is made by incising upward for several centimeters in each vaginal sulcus and undermining the intervening vaginal mucosa, leaving its base intact internally. The flap is then drawn outward to cover the perineum and is sutured to the anus (Fig. 1077).

Where tension is great in other areas, flap formations or relaxing incisions may be indicated. When the skin surrounding the anus was involved and required excision, Taussig has left intact a 1.5 cm. bridge of skin on each side of the anus, the rest of the perianal skin being excised and flaps utilized when necessary to cover the denuded area. The bridges tend to diminish or prevent retraction, scarring, and stenosis of the anal margin. It is said that if these bridges are the site of leukoplakia, this operation will eliminate itching in them, probably through cutting the nerve supply; and they can be removed later if indicated.

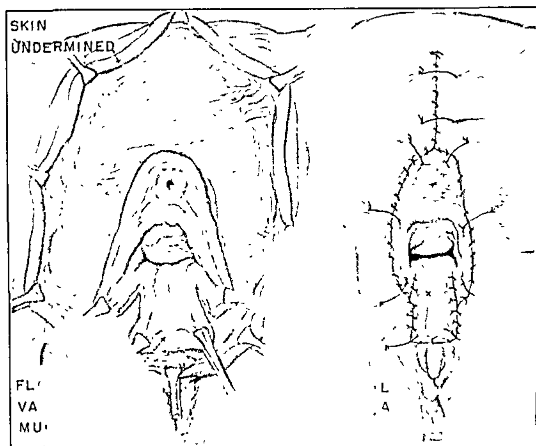



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## RADICAL VULVE...

sig reported a 58.5 per cent five-year survival rate after vulvectomy with Basset adenectomy, 28 6 per cent after vulvectomy with incomplete adenectomy, 8.2 per cent after vulvectomy alone, 4.8 per cent after irradiation alone. Parsons states that "the reports of five-year survival after radiation therapy show on an average a 20 per cent survival rate at best." Irradiation is not well tolerated by the vulva, and x-ray will probably rarely eliminate carcinoma from the regional nodes. These nodes are often involved even when not palpable, and involvement is frequently bilateral. Taussig states that approximately two-thirds of cases of carcinoma of the vulva had lymph node metasasis and that 70 per cent of cancers of the vulva were surgically operable.

The great majority of cancers of the vulva are squamous cell carcinomas arising from the skin. Much more rare are carcinomas of the urethral meatus, the vulvovaginal glands, and the clitoris.

Basset pioneered in the operation for carcinoma of the vulva, advocating for the treatment of carcinoma of the clitoris the simultaneous removal of the vulva, the inguinal nodes, the superfical femoral nodes, and some of the iliac nodes, bilaterally. He did this operation through one incision, joining the anterior iliac spines and including the anterior half or more of the vulva. On each side he cut the inguinal ligament over the femoral ring to expose and remove the important gland thus exposed in the ring. His procedure was modified by Taussig who operated through three separate incisions and who found it rarely necessary to sever the inguinal ligament. The use of separate incisions decreased necrosis and permitted doing the operation in stages; keeping the inguinal ligament intact prevented weakness at this site. Basset's operation, as modified by Taussig, is the operation most highly regarded today. The operation is usually performed in stages, two or three.

First, a wide vulvectomy is done (Figs. 1075-1077). The technic is similar to that already described for leukoplakia. There should be a wide margin about the tumor and any associated leukoplakia should also be included in the excised portion. The incisions are carried down to the deep fascia, the subcutaneous tissues being removed with the skin In closing the wound, when the edges cannot be approximated, the intervening wound may be left to granulate or skin flaps should be used. Wide excision should not be sacrificed in order to obtain complete closure. At the completion of the vulvectomy an indwelling catheter is placed in the bladder.

Two or three weeks later the gland dissection is done. Both sides may be operated upon at this time, but we sometimes prefer to operate upon one groin at a time with an interval of several weeks between the two dissections. The incision for the gland dissection begins at a point 3 to 5 cm. medial to the anterior superior iliac spine and courses downward and medially, crossing the inguinal ligament at an angle of approximately 60 degrees, and ends over the upper portion of the femoral triangle (Fig. 1078). It is usually 10 to 15 cm. in length. The skin is then dissected from the underlying fat and lymph nodes for a distance of two or more centimeters on each side of the incision. The dissected subcutaneous tissue in the upper portion of the wound is then incised to the aponeurosis of the external oblique muscle and the fat and nodes are dissected downward en masse from this structure and from the fascia lata of the thigh to a level 2 to 3 cm. below the inguinal ligament and left overlying the femoral vessels for the time being. The external inguinal ring thus has been exposed (Fig. 1079). The inguinal canal is then opened by incising the overlying aponeurosis of the external oblique muscle (Fig. 1080). This incision begins

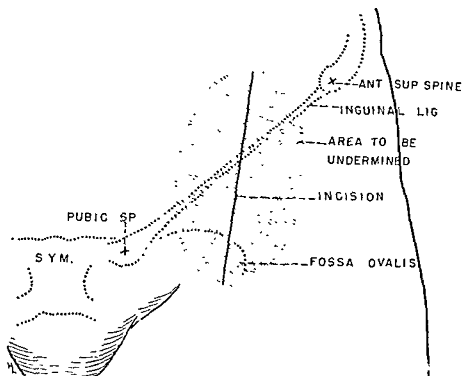



Fig. 1078 —Diagram showing location of incision and extending of undermining of the skin

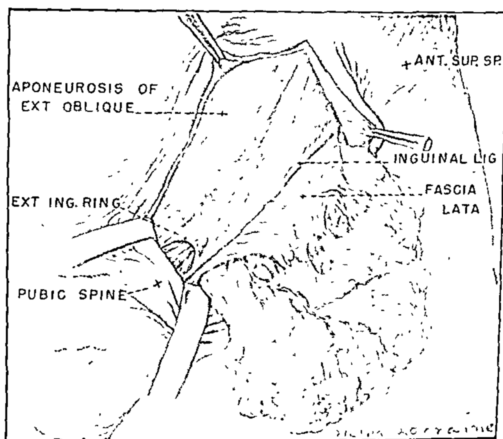



Fig 1079 —Inguinal dissection for carcinoma of the vulva. Subcutaneous tissue including the lymphatics has been dissected from the aponeurosis of the external oblique muscle and from the fascia lata and is left overlying the femoral vessels for the time being. The external inguinal ring is exposed

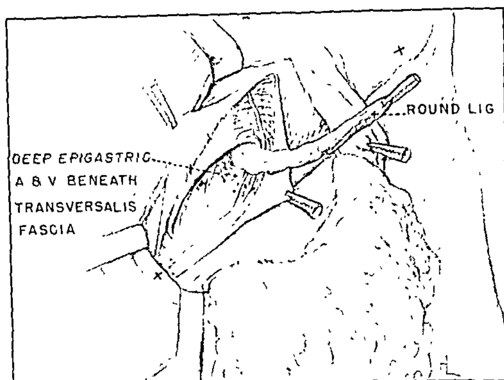



Fig. 1080 —Inguinal dissection for carcinoma of the vulva The inguinal canal has been opened by incising the overlying aponeurosis of the external oblique muscle from the external inguinal ring to above the *internal inguinal ring. The round ligament is being excised.* The *inferior epigastric vessels* are exposed.

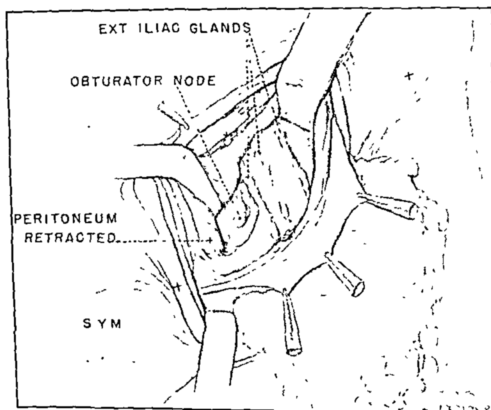



Fig. 1081 —Inguinal dissection for carcinoma of the vulva. The inferior epigastric vessels have been ligated. The internal oblique muscle is *retracted upward,* exposing the external iliac vessels and the external iliac obturator glands. These glands will be removed The dissection is extraperitoneal

fossa ovalis and also at the lowest part of the dissected area, and the intervening segment of the vein and sections of its tributaries excised with the fat and glandular issue (Fig. 1082).

The deep subinguinal glands, lying for the most part in the femoral canal, are then removed, including, if present and palpable, the uppermost one (gland of Cloquet) at the femoral ring. At this point it may be necessary to cut the inguinal ligament overlying the ring.

So far as possible all tissues are removed en masse. If the inguinal ligament has been cut, it is sutured. The regions of the inguinal and femoral canals are closed essentially as in inguinal and femoral herniorrhaphies. The skin margins are united and a compression dressing is applied.

Some men extend the gland dissection even deeper into the pelvis, as in Nathanson's extraperitoneal iliacadenectomy for carcinoma of the cervix, and others feel that dissection as great as Basset's and Taussig's is not necessary. Palmer and his co-writers in a recent article express the latter point of view. The value of extensive regional lymph node dissection in the treatment of cancer in general has been established, and in carcinoma of the vulva there should be no compromise.

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# CHAPTER 76

# THE VAGINA

## OPERATIONS FOR MALFORMATIONS; OPERATIONS ON THE POSTERIOR WALL; OPERATIONS ON THE ANTERIOR WALL

Randolph H. Hoge

## STENOSES AND ATRESIAS OF THE VULVA AND VAGINA

Stenoses and atresias of the vulva and vagina occur and require treatment. Occasionally one finds in an infant agglutination of the labia minora. The relief of this is usually a simple matter. Bilateral pressure on the vulva with the thumbs and simultaneous lateral traction will usually separate the labia without the need for instruments or anesthesia. If this simple procedure is not effective, the labia can usually be separated by passing a probe or a hemostat between them from above and within, downward and outward.

An imperforate hymen, or a rigid hymen, causing dyspareunia, or likely to do so, should be incised in a cruciate fashion and kept open until healing occurs. In the case of hematocolpos or hematometra, no instrumentation should be done above the site of the atresia at the time the atresia is corrected. A small hymen, otherwise normal, is best dilated digitally either by the patient, the doctor, or both.

Occasionally there is a case in which the vaginal opening is too small as the result of abnormality of the perineum. One important cause of this condition is an operation in which the perineum has been sutured too far anteriorly. This diminishes the size of the introitus and tends to place it somewhat anterior to the urethral meatus. Dyspareunia is the usual symptom. Relief is brought about by a surgical procedure to enlarge the vaginal opening. Usually this is done best by making a longitudinal incision across the midline of the perineum, extending upward a short distance into the vagina, undermining the mucosal edges and then suturing the wound so that the line of the closed wound will run transversely (Figs 1083-1085). The depth of the initial incision will vary according to the need. In some instances it will go only through skin and mucosa; in others it will extend a variable distance into the perineal body and may reach, but should not include the sphincter ani Insertion of the left finger into the rectum may serve as a valuable guide during this operation. Occasionally it may be desirable to incise the anterior margins of the levator ani muscles. Constrictions at higher levels of the vagina may be relieved by a similar operation Membranous atresia of the vagina is treated in the same fashion as imperforate hymen, with or without excision of the membrane after it is incised. In the case of congenital duplication of the vagina the septum is excised.

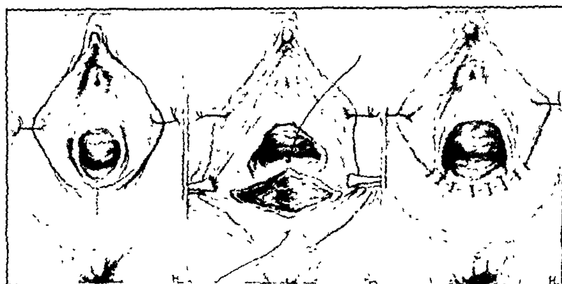


Fig. 1083 Fig 1084. Fig. 1085.

*Fig. 1083*—Stenosis c[illegible] on will be made across the midline of the perineu[illegible] the vagina along the broken line. The depth of [illegible]

Fig. 1084.—Stenosis of the vaginal outlet. The longitudinal incision has been carried in this instance some distance into the perineal body. A suture of No 1 chromic catgut is placed. When tied, this will approximate the upper and lower poles of the initial incision

Fig 1085.—Stenosis of the vaginal outlet. Interrupted sutures of No. 1 chromic catgut have been placed so that the wound now *runs in the transverse direction and the opening has* been adequately enlarged. The temporary sutures on the labia minora will be removed.

## METHODS OF TREATING ABSENCE OF THE VAGINA

In most cases of congenital absence of the vagina the uterus is rudimentary and nonfunctioning, but in any case women with congenital absence of the vagina who are married, or about to be married, should have a vagina constructed. This will permit intercourse and in addition may have a beneficial psychologic effect upon the patient. The operation is also indicated in young unmarried women with *atresia of the* vagina associated with hematometra, the immediate purpose of the operation being the relief of the latter condition. In rare instances uneventful pregnancy and labor have occurred following a construction of the vagina. In these cases, of course, an essentially normal uterus was present.

The correction of congenital absence of the vagina has been attempted for many years. It is said that in 1817 Dupuytren first made an attempt to construct a vagina by opening a space between the bladder and rectum and holding it open with tampons until epithelization of the space took place, but the operation was unsuccessful. Other similar operations with the use of packs proved unsuccessful, but the adoption of rigid molds to be kept in the newly created vaginal space led to many successful operations. Wharton described the use of a mold until epithelization occurs. In his first operation he did not use skin grafts, but he later applied Thiersch grafts about the mold. McIndoe used a vulcanite mold with razor grafts. He sutured the labia minora together and left the mold in place four to six months. Other types of molds and methods of their use have been described by other authors and have met with varied success.

Methods of lining the dissected space have included the use of the ileum (Baldwin), the rectum (Sneguireff), and pedicle grafts from the labia (Graves) and from

*the thigh (Beck; Frank and Geist; Grad).* In a method devised by Falls, a partly attached disk and four small flaps of epithelium from the vestibule or rudimentary vagina are pushed into a partly dissected space and epithelization is *allowed to occur* between them.

A nonoperative method of producing a vagina is that of Frank, who recommended simple pressure with test tubes at the proper site and according to a definite plan. This is said to be the oldest of all methods.

## TECHNIC OF CONSTRUCTION OF VAGINA

It is best to dissect a space between the bladder and rectum, *this being a step* common to all surgical methods in this condition, and then to line the space with split thickness grafts applied on a mold. This method, very similar to some described, is simple, has a high degree of success, and with reasonable care carries little risk for the patient.

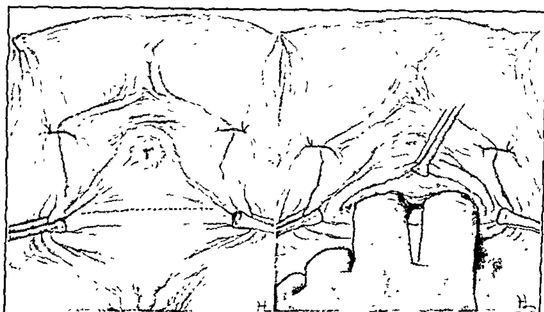
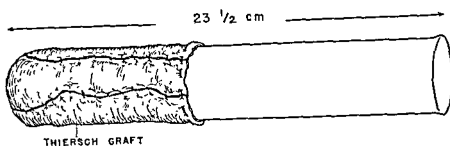


Fig 1086. Fig 1087.

*Fig. 1086.*—Construction of vagina A transverse incision will be made across the vestibule along the broken line.

*Fig. 1087*—Construction of the vagina With the fingers blunt dissection is carried out in the loose connective tissue between the rectum and bladder The space created between these organs *extends to the level of the peritoneum and should admit three fingers* in allowance for subsequent contraction.

*A Foley catheter is placed through the urethra.* Then a transverse incision is made across the vestibule, or rudimentary vaginal pouch if present, at the site where the vagina should be (Fig. 1086). A blunt dissection is then carried out in the loose connective tissue usually present between the rectum and bladder in these cases, separating these organs and extending to the peritoneum (Fig. 1087) On completion this space should be large enough to admit three fingers in allowance for some subsequent contraction. The dissection is usually easy and safe, but if there has been a previous operation it will be less easy and there is increased danger of injury to the bladder or rectum *Complete hemostasis should be obtained* The use of a hot pack may aid in the control of oozing.




[illegible] of vagina *A split thickness* graft has been applied, raw sur-
[illegible] diameter. Fine catgut sutures hold the graft snugly

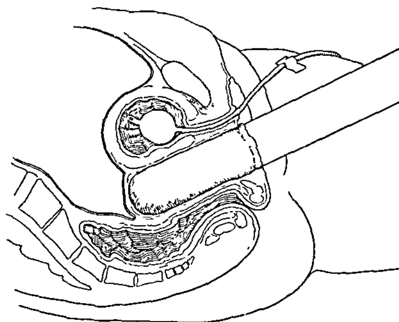


Fig. 1089.—Construction of vagina. Sagittal section showing the tube and graft in the vagina and a Foley catheter in the bladder.

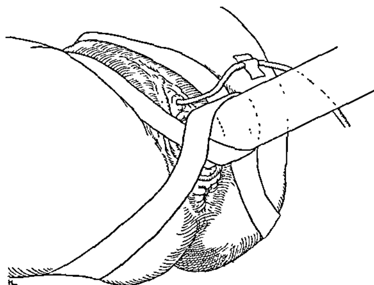


Fig 1090.—Construction of vagina. The tube is held in place with strips of adhesive plaster, running from the abdomen and back to that part of the tube which *protrudes from the* vagina The catheter is strapped to the buttock.

A split thickness skin graft is then taken from the medial aspect of the tl from the lower abdomen. The graft is applied, raw surface outward, to a gla tube 4 cm. in diameter and 23.5 cm. long (Fig. 1088). Fine catgut sutures a to hold the graft snugly but not tightly about the test tube. We avoid a ti or the use of cement for this purpose so that movement of the tube will *not t* pull the graft from the wall of the cavity. The test tube is inserted into the as far as possible and is strapped in place with strips of adhesive plaster ru from the abdomen and back to that part of the tube which protrudes, and it this reason that we prefer the long tube (Figs. 1089 and 1090). The tube a catheter are removed in two to three weeks. By this time the graft has taken same tube, well lubricated, is then used by the patient for dilatation of the several times a day for many weeks or longer, and the patient is kept unde observation. Intercourse after a few weeks will aid in maintaining the size vagina. Without dilatations or intercourse, contracture of the vagina will occ

Antibiotics are given postoperatively until the tube is removed.

## PERINEORRHAPHY

The chief support in the pelvic floor is the musculofibrous sling formed l levator ani muscles and associated layers of fascia. The pelvic floor becomes re usually as a late result of obstetrical injuries, and the repair of the pelvic floor r tions involves chiefly the pelvic sling. The operation is frequently referred to "perineorrhaphy," but it is more than a repair of the so-called "perineum," principally an operation on the much more important sling lying deep to this ture. The operation involves an approach through the overlying mucosa, exp *and shortening of the musculofibrous sling, excision of redundant mucosa, i* and closure of the incision. If the relaxation is associated with a rectocele, the ation is extended to include a repair of the latter condition. Failure to recc and repair an associated rectocele will lead to an unsatisfactory result.

Shortening of the pelvic sling by dissecting out and uniting subvaginally th terior margins of the levator ani muscles was described by Noble in 1897, a 1899 Harris presented a method of shortening this sling by resection of these mu The former is the method now generally used

The first phase of the operation for pelvic floor repair involves the approa and exposure of the fibromuscular pelvic sling. The labia minora are retract suturing them laterally to the skin of the vulva. The base of the vaginal flap elevated and the size of the vaginal introitus postoperatively are determined by ing an Allis clamp on the mucosa of the vestibule just posterior to the openi the duct of the vulvovaginal glands (Crossen) or at the posterior extremity o carunculae myrtiformes on each side. If necessary, the position of these cl should be changed so that when they are approximated the reduced vaginal o ing will freely admit two fingers A ridge of intervening vaginal mucosa at or the mucocutaneous junction is formed by retracting the Allis clamps. This r while on the stretch, is excised with curved scissors (Fig. 1091). The mucosa o posterior vaginal wall is then dissected upward from the incision thus formed. sharp and blunt dissection is used in the procedure and great care must be exer not to enter the rectum. The correct plane of dissection is such that the veins

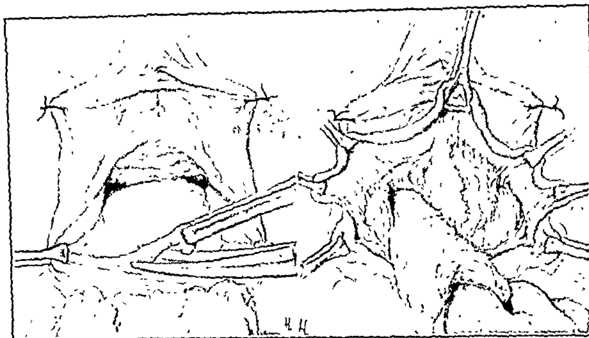



Fig. 1091 Fig. 1092

Fig. 1091.—Perineorrhaphy and posterior colporrhaphy. The labia *minora* are retracted by sutures. Allis clamps have been placed and the ridge of intervening vaginal mucosa at or near the mucocutaneous junction is excised

Fig 1092.—Perineorrhaphy and posterior colporrhaphy. The mucosa of the posterior vaginal wall is dissected upward *from* the incision and is also dissected laterally to expose the margins of the pelvic sling formed by the levator ani muscles

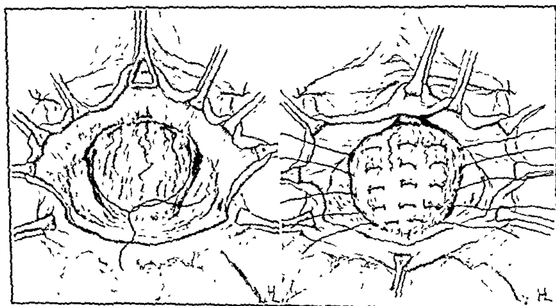



Fig 1093. Fig. 1094

Fig 1093.—Perineorrhaphy and posterior colporrhaphy. The vaginal mucosa is dissected from the rectum to a point well above the apex of the bulge of the rectocele and has been incised in the midline to improve the exposure. The first suture includes a bite of vaginal mucosa

Fig 1094.—Perineorrhaphy and posterior colporrhaphy A complete series of 00 chromic catgut sutures has been placed in the perirectal fascia.

on the rectal rather than the vaginal side. The vaginal mucosa is apt to be quite friable in this area and it is not uncommon to tear the vaginal mucosa during this portion of the dissection.

Occasionally, when there is much dense scar tissue present in the perineal region, it is desirable to open the posterior vaginal wall at a higher level where there is a plane of easy cleavage between the vagina and rectum, and to dissect downward between these structures toward the initial transverse incision. We have on rare occasions found it advisable to put on the left hand a second glove over the first, and insert the left index finger into the rectum to outline the latter and aid in the safe dissection of the vaginal mucosa from the rectum.

The further the dissection is carried laterally and upward the easier it becomes, and dissection with the finger wrapped in gauze may be useful in these areas (Fig. 1092). The upward extent of the dissection is determined in part by whether an associated rectocele is present. If no rectocele is present, the dissection is carried upward only sufficiently high to permit exposure and suture of the pelvic sling. The dissection is carried quite far laterally, so that the anteromedial margin of the levator ani muscle, covered with its fascia, is identified and well exposed. Identification is aided by passing the index finger laterally and downward from the rectum to palpate the firm shelflike structure of the muscle margin.

This brings us to the second phase of the operation, namely, shortening of the pelvic sling through coaptation of the levator ani muscles and associated fascia in the midline between the anus and vagina (Figs. 1095 and 1096). The levator muscles with the associated fascia are grasped with Allis clamps and are sutured together, using interrupted sutures of No. 1 chromic catgut. Only two or three of these sutures are usually necessary, and care must be taken that when they are tied the vagina at this stage will admit three fingers.

The final phase of the operation is closure of the wound At the beginning of this phase any redundant mucosa is excised (Fig. 1096). This usually means the excision of a triangle of tissue, the amount varying according to the redundancy. The apex of the triangle is marked with an Allis clamp. If a rectocele has been simultaneously repaired, the apex extends higher than otherwise. Great care must be taken not to excise too much mucosa and when in doubt it is better to excise it piecemeal to the proper amount, rather than run the risk of excising too much in one piece. Enough mucosa should remain to permit the passage of two fingers freely into the entire vaginal canal at the completion of the operation, if the patient is to be sexually active.

The mucosa having been excised, then tissues in the "perineal" area external to the pelvic sling are sutured with one or two layers of No. 1 chromic catgut (Fig. 1096). Following this the cut edges of vaginal mucosa are then approximated in the midline with a continuous locked suture of chromic catgut, and this suture is continued onto the skin, thus completing the closure of the entire wound (Fig. 1097).

All bleeding is carefully controlled during the operation. At the completion of the closure a gauze pack is placed in the vagina to obliterate dead spaces and control oozing; it is to be removed in twenty-four hours. The retracting sutures are removed from the labia minora and the operation is complete.

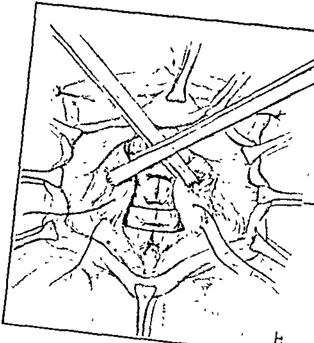




Fig. 1095

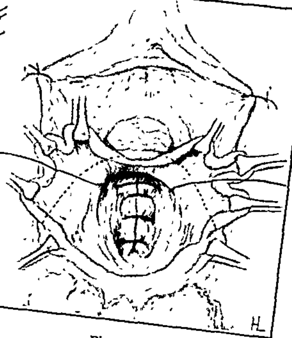




Fig. 1096

Fig 1095—Perineorrhaphy and posterior colporrhaphy. The perirectal sutures have been tied Clamps grasp the medial margins of the levator ani muscles in which several chromic catgut sutures are taken to approximate these muscles and associated fascia in the midline between the anus and vagina

Fig. 1096—Perineorrhaphy and posterior colporrhaphy. The levator muscles have been approximated The dotted line shows where redundant vaginal mucosa will be excised Perineal tissues external to the united levator ani muscles are closed with one or two layers of interrupted sutures of No 1 chromic catgut One such suture has been placed

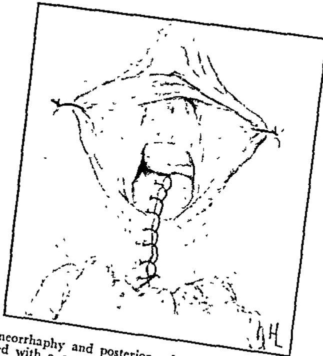




Fig 1097—Perineorrhaphy and posterior colporrhaphy. The margins of the mucosa have been approximated with a continuous locked suture of chromic catgut which was continued onto the skin The sutures in the labia minora will be removed.

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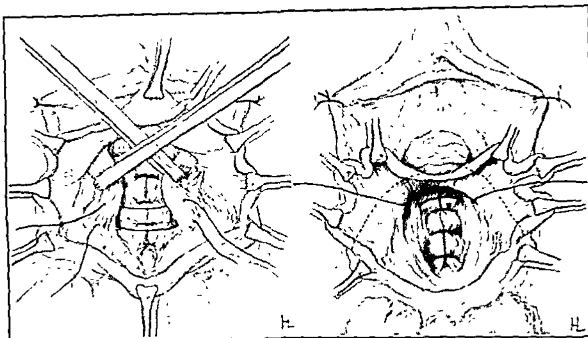


Fig. 1095. Fig. 1096.

Fig. 1095.—Perineorrhaphy and posterior colporrhaphy. The perirectal sutures have been tied. Clamps grasp the medial margins of the levator ani muscles in which several chromic catgut sutures are taken to approximate these muscles and associated fascia in the midline between the anus and vagina

Fig. 1096.—Perineorrhaphy and posterior colporrhaphy. The levator muscles have been approximated The dotted line shows where redundant vaginal mucosa will be excised. Perineal tissues external to the united levator ani muscles are closed with one or two layers of interrupted sutures of No. 1 chromic catgut. One such suture has been placed

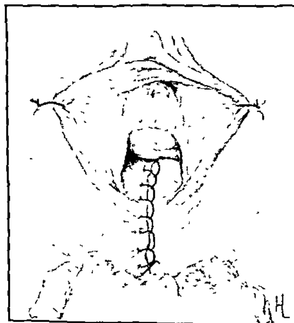


Fig. 1097.—Perineorrhaphy and posterior colporrhaphy. The margins of the mucosa have been approximated with a continuous locked suture of chromic catgut which was continued onto the skin. The sutures in the labia minora will be removed.

## REPAIR OF RECTOCELE: POSTERIOR COLPORRHAPHY

For small rectoceles the procedures described for repair of a relaxed pelvic floor are adequate. For larger rectoceles the same procedures (Figs. 1091 and 1092) are carried out, but the vaginal flap is dissected higher (well above the apex of the bulge) and incised longitudinally if necessary; and then steps are taken to reduce the redundancy of the rectum. The latter is usually accomplished by taking mattress sutures of 00 chromic catgut in the perirectal fascia in a manner to plicate the rectal wall (Fig. 1093), or in some instances by taking concentric purse-string sutures to invaginate the rectal wall (Fig. 1094). The margins of the levator ani muscles are then approximated and the operation is completed as described for a relaxed pelvic floor (Figs. 1095-1097).

## REPAIR OF ENTEROCELE

Much more rare than relaxations of the pelvic floor or rectocele is the herniation through the rectouterine fossa known as enterocele. It may be present alone and mistaken for a high rectocele or it may be associated with the latter and overlooked. It may be associated with uterine prolapse. Failure to correct it during a repair will result in at least a partial failure of the operation.

The operation for repair of an enterocele consists of exposing the sac of peritoneum, dissecting it free, reducing its contents, and excising it. The neck may be ligated with No. 1 chromic catgut before the excision, or the excision may be done first and the opening in the peritoneum then sutured. The cervix is then drawn forward and the uterosacral ligaments identified and sutured together in the midline and to the cervix with several interrupted sutures of No. 1 chromic catgut, thus reinforcing the base of the rectouterine fossa. The mucosa is then closed. The operation for enterocele is usually a part of a more extensive vaginal operation, and the incision and subsequent closure are integrated with the other part of the operation An enterocele may be repaired transabdominally by the use of a series of purse-string sutures to obliterate the hernial sac and rectouterine fossa. Here nonabsorbable sutures may be used

## REPAIR OF COMPLETE PERINEAL LACERATION

Proper preparation of the patient is particularly important in this operation. Local infection should be cleared up and the bacterial content of the bowel should be decreased through the use of penicillin, streptomycin, and Sulfathalidine or Sulfasuxidine. During this same period the patient should be on a light low-residue diet, liquids only being given the day before operation. Cathartics and enemas should be used to have the large bowel empty at the time of operation.

The technic of repair involves the same steps as described in the repair of a relaxed pelvic floor, with certain important modifications and additions. The latter are necessary because the sphincter ani muscle must be repaired and the injury to the rectum corrected.

The flap method, in which an apron of vaginal mucosa is turned down, is a valuable operation. It was first described by Warren and further developed by a number of operators. It is the one preferred.

The first step is to stretch the lacerated sphincter ani muscle which has become straightened out and shortened. Its widely separated ends are usually marked by dimpling of the overlying skin, and the intervening overlying posterior anal mucosa is thrown into folds. The stretching is done manually by grasping the tissues at each end of the sphincter and putting the intervening tissues on the stretch.

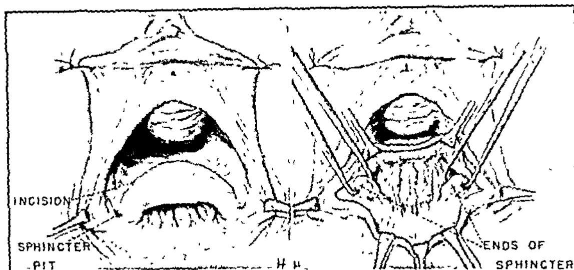



Fig. 1098 Fig. 1099.

Fig 1098—Repair of complete perineal laceration Flap method An incision through the vaginal mucosa will be made an indicated 2 cm. or more above the *rectovaginal margin.* It is carried on each side to a point anterior to the dimpling over the retracted end of the anal sphincter

*Fig* 1099—Repair of complete perineal laceration. Flap method. The lower flap of vaginal mucosa has been turned down to expose the ends of the sphincter.

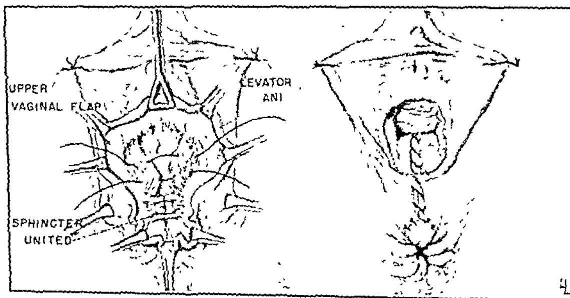



Fig 1100 Fig. 1101.

Fig 1100—Repair of complete perineal laceration. Flap method. The ends of the sphincter ani have been sutured together with interrupted sutures of No. 1 chromic catgut. The upper vaginal flap has been dissected and the levator ani muscles are approximated with interrupted sutures of the same material

Fig 1101—Repair of complete perineal laceration. Flap method. The more superficial tissues of the perineum, the vaginal mucosa, and the skin are sutured with catgut. A portion of the lower vaginal flap protruding through the anus anteriorly is sutured to the perineal skin.

Then the rectovaginal septum is opened by transverse incision through the vaginal mucosa about 2 cm. or more above the rectovaginal margin (Fig 1098). The incision is carried laterally and slightly downward on each side to a point anterior to the dimpling over the retracted end of the anal sphincter. The lower flap of vaginal mucosa is then turned downward to expose the ends of the sphincter (Fig. 1099). Care must be exercised not to buttonhole this flap or to carry the dissection too close to its lower attached margin.

The ends of the sphincter ani muscle are then identified and sutured together anteriorly with interrupted sutures of No 1 chromic catgut (Fig. 1100). The upper vaginal flap is then dissected and the levator ani muscles are approximated as in a simple repair of the perineum This is an important step and may help in the reestablishment of fecal continence. The more superficial tissues of the perineum, the vaginal mucosa, and the skin are then sutured in order (Fig. 1101).

The lower vaginal flap has thus served to fill the deficiency in the anterior rectal wall, obviating suture of the rectum, and at the same time has lessened contamination from the rectum. A portion of this flap will protrude anteriorly from the reconstructed anus and may be trimmed if necessary and sutured to the perineal skin anteriorly.

Some advocate, as the final step in the operation, the subcutaneous cutting of the anal sphincter to relieve tension on the ends sutured anteriorly, in which case the sphincter is incised posterolaterally. Miller and Brown and others attributed increased success to the addition of this step.

If the flap method is not used, the initial line of incision is made at the margin of the tear, the vaginal mucosa is dissected upward, and the rectal wall is sutured. Interrupted silk sutures may be used in the rectal wall with their knots lying within the rectal lumen. From then on the technic of the repair is similar to that described above.

The postoperative care is important and is similar to that to be described for repair of a rectovaginal fistula. The full benefit of the operation may not be realized for weeks or months.

## REPAIR OF RECTOVAGINAL FISTULA

Preoperative preparation is very important in this operation and is the same as that already described in the repair of complete lacerations of the perineum.

The technic of the repair of a communication between the rectum and the vagina will depend on many factors, including the etiology of the condition, the size of the opening and its location, the condition of the tissues, and the presence of associated lesions. No single description will be applicable to all cases In general, the operation consists essentially of fairly wide separation of the rectum and vagina about the opening, with mobilization of the rectum particularly, as the first step; and separate closure of the rectal and vaginal openings as the second step. The manner in which these procedures are done will vary with circumstances, and in some instances more than one method is applicable to a given case. If the fistula is very low and if associated with a deep or complete laceration of the perineum, it may be advisable to make a vertical incision through the rectovaginal septum from the anus to the fistulous opening, and then proceed as in repairing a complete perineal laceration by the nonflap method. If the fistula is low and associated with

a more moderate degree of perineal relaxation, the beginning and the end of its repair are similar to that of the usual perineorrhaphy, with the openings in the rectum and vagina being closed as intermediate steps after adequate mobilization of these organs. If the opening is very high in the vagina, as in the posterior fornix,

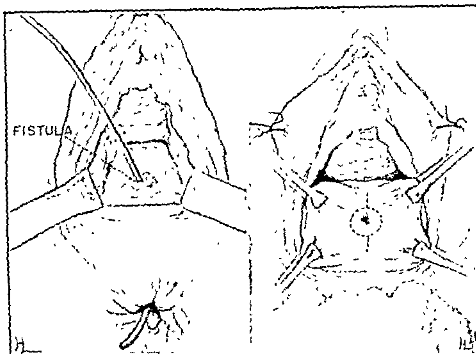



Fig 1102. Fig. 1103.

Fig. 1102.—Repair of rectovaginal fistula. A probe has been passed through a small rectovaginal fistula present in the midline of the lower half of the vagina.

Fig 1103.—Repair of rectovaginal fistula. The vaginal mucosa has been grasped with Allis clamps and elevated to form a flat square surface about the fistula. An incision is made along the circular broken line and, when indicated, may be extended along the vertical lines.

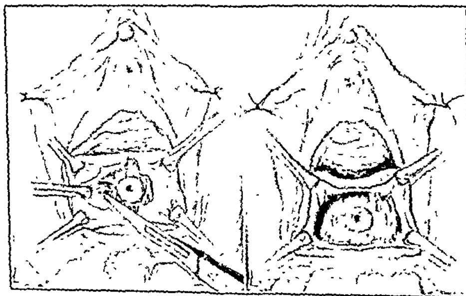


Fig. 1104. Fig 1105

Fig 1104—Repair of rectovaginal fistula The vaginal mucosa is elevated from the rectum and perirectal fascia in a centrifugal direction from the circular incision.

Fig. 1105.—Repair of rectovaginal fistula. The peripheral dissection has been completed, widely mobilizing the rectum about the fistulous opening.

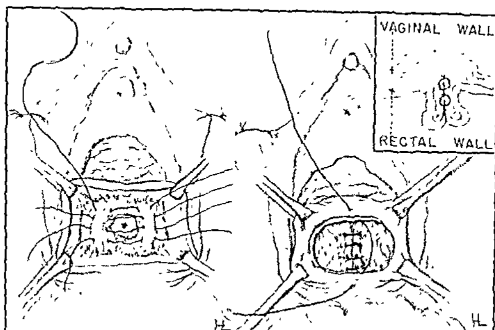



Fig. 1106. Fig. 1107.

Fig. 1106.—Repair of rectovaginal fistula A row of interrupted mattress sutures of chromic catgut *are placed in the perirectal fascia and rectal muscularis close to the fistulous* opening. These sutures avoid the rectal mucosa.

Fig. 1107.—Repair of rectovaginal fistula The sutures about the fistulous opening have been tied and, as shown in the inset, tend to invaginate the fistulous opening into the rectum The first stitch for the closure of the vaginal wound has been placed

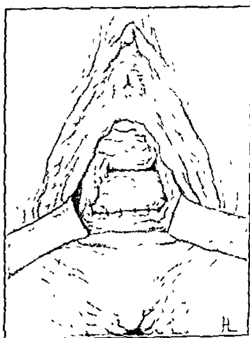


Fig. 1108.—Repair of rectovaginal fistula The vaginal wound has been closed with *interrupted sutures of chromic catgut in such a manner* that the line of closure will run transversely.

and the lesion is not adequately accessible from below, it may be desirable or necessary to use a transperitoneal approach. In cases in which there is a very large opening, or in which the tissues are indurated and fixed, preliminary temporary colostomy may be indicated. In very rare instances the vagina may have to be obliterated. No attempt should be made to close a fistula in the presence of carcinoma, or a fistula that has recently resulted from the application of radium.

In a small uncomplicated fistula in the middle or lower part of the vagina (Fig. 1102) the repair may be done as follows, and the described technic with appropriate modifications is applicable to most cases of this disorder.

The vaginal mucosa is grasped with four Allis clamps and elevated to form a flat square surface in the center of which is the fistula (Fig. 1103). With a small-bladed scalpel a circular incision is made through the vaginal mucosa about and very close to the margin of the fistula. Then the vaginal mucosa is elevated from the rectum and perirectal fascia in a centrifugal direction from the circular incision to give better exposure for wider mobilization (Figs. 1104 and 1105). This is done with sharp dissection, using the small scalpel or the scissor tips, or both; and when one gets further from the opening blunt dissection also may be useful.

When mobilization is sufficiently wide, the rectal opening is closed (Fig. 1106). For this 0 or 00 chromic catgut is used, and the sutures are placed in the perirectal fascia and rectal muscularis close to the opening and not in the rectal mucosa. When the opening is tiny, one or more purse strings may be used, but in most cases several interrupted transverse mattress sutures are used, approximating broad surfaces over the fistulous opening and tending to invaginate the latter toward the rectum. It may be desirable to use one or more additional layers of these sutures if there is sufficient relaxation of the rectal wall (Fig. 1107).

When the rectal opening of the fistula has been closed, the cut margins of the vaginal mucosa are approximated with interrupted No. 1 or 0 chromic catgut sutures, thus closing the vaginal opening of the fistula. It is usually desirable to close the vaginal incision in such a manner that the line of closure will run transversely, this is, to make the vaginal line of closure at right angles to the rectal line of closure and also to prevent narrowing of the vagina (Fig. 1108).

In rare instances in difficult cases the sphincter ani should be cut to prevent subsequent distention of the rectum. A suitable site for this step is at "4 o'clock." Healing should occur spontaneously without residual incontinence.

The postoperative care is quite important. For a number of days the antibiotics and sulfonamides used preoperatively should be continued, the patient should be placed on a liquid diet, the bowels should not move, and rectal medications, etc., should be avoided. After about five days mineral oil is given and the patient is permitted to have a soft stool without straining. Coitus is prohibited for several weeks.

Many of these statements apply, with obvious modifications, to the repair of vesicovaginal fistulas, a subject dealt with in the urological section of these volumes.

## POSTERIOR COLPOTOMY

Vaginal drainage of a pelvic abscess is sometimes a procedure of value for its palliative and occasionally curative effect. The procedure is not advocated unless

and until the abscess is fixed to the floor of the rectouterine fossa and there is fluctuation and bulging palpable on vaginal or rectovaginal examination.

Drainage is made through the posterior vaginal fornix where only a thin septum separates the vagina from the rectouterine fossa. The cervix is caught with a tenaculum and drawn forward. We regard it as wiser then to insert a long hollow needle close to the cervix and into the fluctuant area and attempt to aspirate fluid into an attached syringe (Fig. 1109). If pus is found, an incision is made trans-

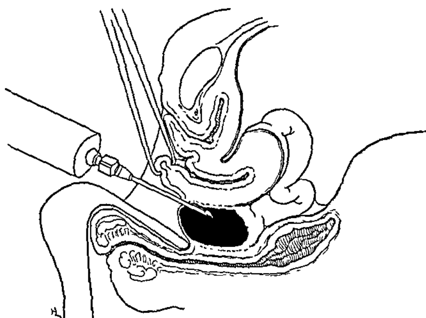


Fig. 1109.—Posterior colpotomy. The posterior lip of the cervix is caught with a tenaculum and drawn forward. A long hollow needle attached to a syringe is inserted close to the cervix into a pelvic abscess.

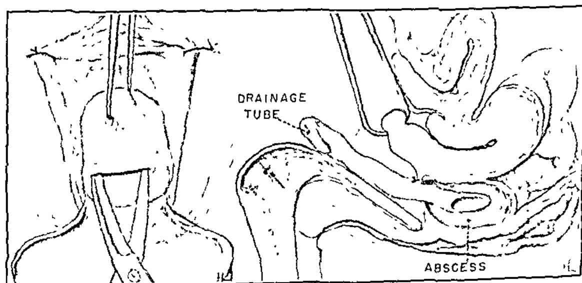



Fig. 1110 Fig. 1111.

Fig. 1110.—Posterior colpotomy. A transverse incision has been made through the vaginal wall along or very close to the line of its reflexion onto the cervix. The opening is enlarged and continued to the peritoneum

Fig. 1111.—Posterior colpotomy. The incision through the posterior vaginal fornix into the abscess cavity has been made. A soft rubber drain has been inserted into the cavity and sutured in place with catgut.

versely through the vaginal wall along or very close to the line of its reflexion onto the cervix (Fig. 1110). Then with blunt dissection using the finger or a clamp or by separating the blades of scissors, the opening is enlarged and continued to the peritoneum, care being taken not to injure the rectum. The peritoneum is then opened with scissors and the opening enlarged by blunt dissection, as by separating the ends of a clamp held in the wound. The pus is allowed to drain out; no irrigation is performed. A soft rubber tube or a Penrose drain is inserted into the cavity, sutured with catgut to the opening, and left in for a few days (Fig. 1111). A hard tube should not be used because of the danger of erosion into the rectum or through the abscess wall Rarely it is desirable to dilate the opening again later for further drainage.

In the case of a pelvic abscess so drained laparotomy may or may not be indicated later. If, at the time of the initial aspiration, no pus is obtained, the colpotomy is not done If old blood is obtained, this finding in most instances is diagnostic of extrauterine pregnancy and a laparotomy is indicated.

## CYSTOCELE

If a cystocele is large, produces adequate symptoms, or is associated with other conditions requiring vaginal repair, surgical treatment is indicated. In general, the larger and more symptomatic the cystocele, the better is the result of operation The repair of a small cystocele is more apt to be disappointing to the patient. During the childbearing period the indications for operation must be stronger than when childbearing is no longer possible. However, simple and effective repairs of the anterior vaginal wall should not interfere with labor, and there is usually no tendency for recurrence of the cystocele following childbirth, though the risk of recurrence exists

In this chapter will be discussed only the repair of a cystocele unassociated with appreciable prolapse of the uterus. Simple surgical methods are preferable if the results are good. The anterior colporrhaphy to be described is a simple method which gives very satisfactory results. More complicated methods may be indicated in special cases, but the operation outlined, or a similar procedure, is preferable for the great majority of cases. The essential steps in this operation are to mobilize and elevate the bladder by advancing it on the cervix and to support it further by rebuilding the underlying fascial structure.

### Technic of Repair of Cystocele

The patient is prepared for a vaginal operation and is in the lithotomy position A bimanual examination is done and the labia minora are sutured to the labia majora A weighted vaginal speculum is placed posteriorly, the anterior lip of the cervix is grasped with a bullet forceps or a double-toothed tenaculum, and a routine dilatation and curettage are done. Then, with moderate traction being exerted on the cervix through the tenaculum, a transverse incision is made in the anterior fornix at the junction of the vaginal mucosa and the cervix just below the margin of the bladder attachment. The incision is carried down to the cervical tissue Care must be taken not to incise the bladder. An Ochsner clamp is then placed on the anterior margin of the incision just to each side of the midline. Then, with moderate traction continued through these clamps, the tips of curved scissors

are inserted under the vaginal wall in the midline (Fig. 1112). The scissors are pushed forward in the midline under the vaginal wall, being alternately opened and closed, and forming a tunnel through a natural plane of cleavage between the portion of the pubovesicocervical fascia attached to the vaginal mucosa and the fascia intimately adherent to the bladder. The term *pubovesicocervical fascia* is used here and elsewhere in the text to designate this tissue because of common acceptance of this designation. However, there is evidence that this tissue is actually muscle of the vaginal wall. When the scissors are in the process of undermining, their curve is kept so that their tips point toward the vaginal mucosa and thus away from the bladder. After tunneling a short distance, the vaginal mucosa and attached fascia is incised in the midline for almost the length of the tunneling. Then Allis clamps are placed bilaterally at the upper end of the newest incision, traction is exerted through them, and the scissors are reinserted Undermining, cutting, and clamping are thus alternately performed until the incision is carried under the urethra, usually stopping 1 to 2 cm. short of the urethral meatus (Fig 1113). In cases in which the cervix cannot be drawn to the introitus, the direction of the foregoing dissection may have to be reversed; i e, made from urethra to cervix. In either case, on completing this phase of the dissection, an Allis clamp is placed on the mucosa at the anterior pole of the incision. The mucosal flap on the patient's right side is then elevated and held taut with the clamps which have been placed on its margin. Attached to the deep surface of this mucosa is a usually well-defined layer of pubovesicocervical fascia. This layer is to be separated from the vaginal mucosa, as to be described, and left attached to the bladder except in the midline. To accomplish this an incision with a scalpel is made through this fascia near and parallel to the margin of the flap for its entire length. This layer of fascia is then stripped from the deep surface of the mucosa as far lateral as the lateral vaginal wall. Blunt dissection with gauze spread over the finger is a good method for this (Fig. 1114) During both the sharp and blunt dissection of this fascial layer it may be helpful to keep the index finger of the left hand on the external surface of the mucosa to aid in keeping it taut and to gauge the depth of the dissection and prevent buttonholing. On completion of the separation of the mucosa and fascia on the right side, the procedure is repeated on the left.

The next step is to separate the bladder from the cervix. The bladder is picked up with fingers or forceps and the denser fibers passing between it and the cervix are snipped with scissors (Fig 1115). The separation of the two organs is completed by gauze dissection upward until the vesicouterine peritoneal reflexion is reached (Figs. 1116 and 1117). Anterior retraction of the bladder causes the pubovesicocervical fascia to stand out as bundles of tissue on each side (Fig. 1118).

Sutures are now taken to plicate the pubovesicocervical fascia and to fix the bladder at a higher level on the uterus. To accomplish the former, interrupted sutures of 00 chromic catgut are taken in the pubovesicocervical fascia attached to the bladder, one or more bites of tissue being taken on each side of the midline. These sutures are tied, forming one or more longitudinal pleats. Usually one row of such sutures is sufficient, but in very large cystoceles an additional one or two overlying rows may be used When the plication over the bladder is complete, interrupted sutures of No. 1 chromic catgut are taken between the lateral fascial bundles previously described and the anterior surface of the cervix. These sutures,

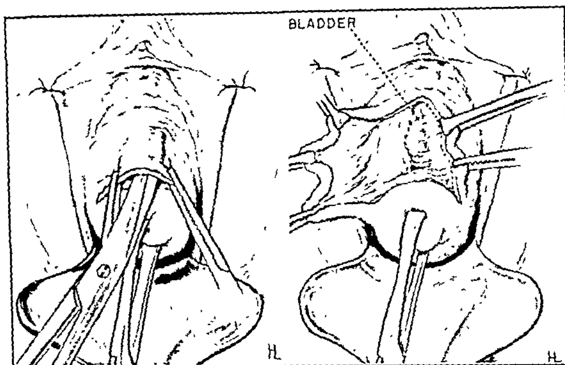



Fig 1112. Fig 1113.

Fig 1112.—Repair of cystocele *A transverse incision has been made at the junction of the vagina and cervical mucosa. While traction is exerted, curved scissors, with tips pointed outward, are inserted under the vaginal mucosa and so-called pubovesicocervical fascia*

Fig 1113 —Repair of cystocele *On the patient's right the so-called pubovesicocervical fascia has been separated from the vaginal mucosa, leaving this fascia attached to the bladder. The dotted line on the left shows where the incision will be made for a similar dissection.*

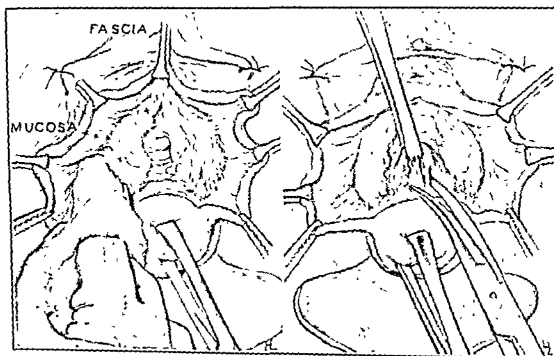



Fig 1114 Fig 1115.

Fig 1114 —Repair of cystocele. The separation of pubovesicocervical fascia from the vaginal mucosa on both sides is almost complete.

Fig 1115 —Repair of cystocele The lower margin of the bladder is grasped and the denser fibers extending between the bladder and cervix near the midline are cut.

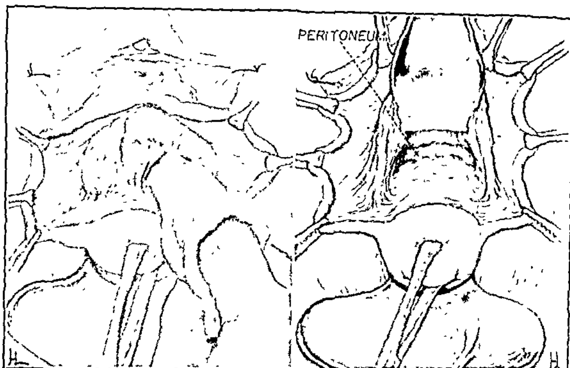



Fig. 1116. Fig. 1117.

Fig. 1116.—Repair of cystocele. The rest of the separation of the bladder and cervix is accomplished easily by blunt gauze dissection

Fig 1117.—Repair of cystocele. The separation of the bladder and cervix has been completed by dissection to the level of the vesicouterine fold of peritoneum. The bladder is retracted anteriorly, making the pubovesicocervical fascia stand out laterally as bundles or pillars

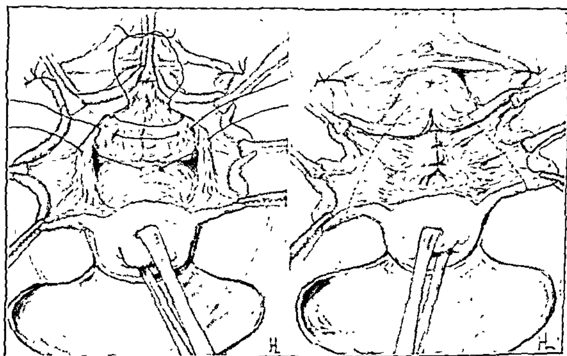


Fig 1118 Fig 1119

Fig. 1118.—Repair of cystocele Interrupted sutures have been placed in the fascia attached to the bladder. One or more bites of tissue are taken on each side. Posteriorly interrupted sutures will be taken between the fascial bundles and the cervix: one such is illustrated

Fig 1119—Repair of cystocele. All sutures have been tied, thus completing the re-building of the fascia under the bladder, elevating the bladder, and holding the bladder in its advanced position on the cervix. Redundant vaginal mucosa will be excised.

when tied, bring the fascia together in the midline and fix the bladder in its advanced position above the level of the internal os (Figs. 1118 and 1119). Occasionally, before the lateral fascial bundles are sutured to the cervix, sutures may be taken between the cervix and the posterior margin of the already sutured fascia attached to the bladder. Following completion of the fascial suturing, the redundant vaginal mucosa is excised and the mucosal edges are approximated with interrupted sutures of No. 1 chromic catgut (Fig 1120). Care must be taken not to excise too much mucosa. Hemostasis has been maintained throughout the operation. If no other vaginal operation is to be done, a gauze pack is placed in the vagina and a Foley catheter placed in the bladder. The former is removed the next day, and the latter is left in place for three to five days.

As has been stated, the foregoing procedure is adequate for the correction of cystocele in the great majority of cases. It may be modified when occasion indicates, as when it is combined with other operations for the relief of associated conditions.

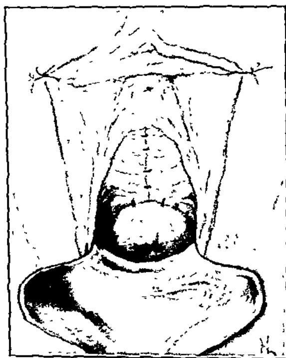


Fig 1120.—The vaginal mucosa has been sutured with interrupted sutures and the operation is complete.

Conditions which quite commonly accompany cystocele are urethrocele, stress incontinence of urine, prolapse of the uterus, diseases of the cervix, and relaxed pelvic floor. The operation for the correction of cystocele should then be modified or extended or combined with other operations to correct all of these conditions. The surgical treatment of urethrocele and stress incontinence will be discussed in this chapter; the correction of the other conditions will be discussed in other chapters.

## URETHROCELE AND STRESS INCONTINENCE

Stress incontinence can be defined as the involuntary passage of urine through the urethra due to incompetence of the sphincter mechanism and occurring typically only on exertion. It is generally a late result of childbirth injury. Urethro-

cele is a downward protrusion of the urethra, also a result of parturition. Urethrocele and stress incontinence may occur separately or together, and either or both may be, and frequently are, associated with cystocele. When so associated, the cystocele is usually repaired as already described, but the vaginal incision is made to extend closer to the urethral meatus and there is more dissection of the bladder neck and urethra, and additional suturing is done in these areas.

Despite much work on the subject, the anatomy of the urethra, the physiology of micturition, and the pathology of stress incontinence are all imperfectly understood. Because of this, and also because of the probably related fact that failure apparently occurs in about 20 per cent of cases treated, numerous operations have been devised for the treatment of this type of incontinence.

According to one writer, the one thing that all of the operations have in common is that the originator of each operation thinks his method gives the best results. We find that each operation has one or more of the following characteristics: (1) the sphincter muscles are tightened; (2) the fascial layers about the urethra are tightened; (3) the lumen of the urethra is narrowed; (4) the urethra is lengthened; (5) the urethra and often the bladder with it is elevated; (6) support is placed under or constriction made about the urethra through the use of transplanted fascial or muscle strips or foreign bodies. Nonsurgical methods have included the use of estrogens and exercises and the treatment of urinary tract infections.

### Kelly Repair and Modifications

One of the simplest, best, and most often used surgical methods of treating stress incontinence is the method which was described by Kelly in 1913, or one of its modifications. Kelly put a Pezzer catheter into the urethra and made a midline incision through the vagina under the urethra and bladder neck, exposing these and dissecting the vaginal mucosa laterally. Traction was exerted on the catheter, thus locating the bladder neck. The tissues about the bladder neck were then approximated with two or three mattress sutures of silk or linen, thus shortening the relaxed or torn internal sphincter. The catheter was removed before the sutures were tied In the belief that injury to muscles and fascia external to the internal sphincter play an important part in stress incontinence, modifications of Kelly's operation have been devised which extend the plication more or less the entire length of the urethra (4 to 4.5 cm.). TeLinde uses such a method. Kennedy does this in combination with a dissection to free adhesions between the urethra and the pubic rami. Counseller reports 100 per cent success with the Kennedy method. We have usually used an extension of Kelly's method similar to TeLinde's, plicating the tissues about the bladder neck and entire urethra, and using interrupted sutures of 00 chromic catgut to do this. Occasionally a second and overlying row of sutures is necessary. No catheter should be in place when the sutures are tied. Any redundant vaginal wall is excised and the cut edges approximated with interrupted sutures of No. 1 chromic catgut.

### More Radical Operations for Stress Incontinence

When, in a given case, one or more simple procedures such as the foregoing have failed, more complicated procedures must be considered. One such is the Aldridge operation in which a Kennedy type of repair is combined with the trans-

plantation of strips from the anterior sheaths of the rectus abdominis muscles and the aponeuroses of the external oblique muscles to form a sling under the urethra. Thus, contraction of the rectus abdominis muscles elevates and compresses the urethra. Several other operations make use of fascial or muscle bands brought down from the abdominal wall or from elsewhere. Marshall and co-writers describe an operation in which suture of the vesical neck and the urethra to the pubis and rectus abdominis muscles through an abdominal approach and without operation under the urethra and bladder has proved successful in selected cases.

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# CHAPTER 77

# THE VAGINA (CONTINUED)

## OPERATIONS FOR UTERINE PROLAPSE

RANDOLPH H. HOGE

## INTRODUCTION

No longer are intra-abdominal operations performed as a part of the treatment of prolapse of the uterus, except by a few operators, or under unusual circumstances, or unless there is intrapelvic disease requiring laparotomy. One finds wide difference of opinion, however, regarding the best type of vaginal operation for this condition. The chief difference of opinion regards the relative merits of vaginal hysterectomy and the Manchester type of repair.

It is important in prolapse of the uterus, as in many conditions, that no rigid routine be set up for the treatment of all cases. Rather, the surgeon should have knowledge of, and skill in, various methods of treatment; he should consider each case individually and should select the treatment that seems best for the particular case if operated upon by him. In making a decision as to the type of surgery, the following factors must be considered judiciously: the age and general condition of the patient; the sexual function; the desirability or possibility of future pregnancies; the degree of prolapse; the size and intrinsic condition of the uterus; the presence of other associated conditions such as cystocele, rectocele, enterocele, and intrapelvic lesions, and to some extent the relative skill of the operator in the various methods.

Prolapse is associated in most cases with cystocele, frequently with urethral disturbances and relaxations of the pelvic floor, often with disease of the cervix, and occasionally with enterocele. Any operation for prolapse should correct simultaneously these other conditions

Fortunately most women with prolapse already have had children, and many are past the menopause. In women capable and desirous of having children, surgical correction of the prolapse is postponed and a pessary is used if symptoms warrant it. If surgery is used in these younger patients desiring children, it should be of a conservative character. For example, uterine suspension may be done for its limited effect, with or without limited vaginal repair.

In the majority of patients, where the need to conserve the childbearing function is not a factor, we have relied on either the Manchester operation or vaginal hysterectomy. There should be no set rule; but, in general, if the uterus is intrinsically diseased, or if the prolapse is complete, vaginal hysterectomy is preferred; if the prolapse is incomplete and the uterus healthy, a Manchester operation is done. Often the decision between the two is not made until the operation has been started

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## MANCHESTER OPERATION

The forerunner of this operation, as done today, was an operation originated in Manchester, England, by Donald in 1888. Subsequently the operation was further developed by Fothergill and by Shaw, both of Manchester, and by numerous others. Various modifications of the original operation are used today; all of these have in common amputation of the cervix, suturing of the cardinal ligaments anterior to the cervical stump, and repair of the associated cystocele and relaxed pelvic floor. Suturing of the elongated cardinal ligaments anterior to the cervix takes up the slack in these important supportive structures, and tends to elevate the uterus and draw the corpus forward.

Shaw has gone so far as to state that the Manchester operation has been performed in that city for years by a large number of gynecologists "upon all patients with prolapsus uteri, irrespective of age, social position, or parity, and that the results allow more nearly a guarantee of cure to be given the patient beforehand than does any other operation in surgery." He stated that 95 per cent of 549 cases were cured, that the operation was not a cause of trouble in subsequent labors, and that there was recurrence after labor in less than 25 per cent of the cases.

There may be only a few who will agree that the cure rate is as good as indicated by Shaw, or that subsequent labor may not cause trouble. Nevertheless the operation is a popular one, simple in performance, without great risk to the patient, and followed by satisfactory results in a high percentage of cases

### Technic of the Manchester Operation

The first phase of the operation is the same as the dissection carried out in cystocele repair. In this phase the anterior vaginal wall is dissected and the bladder mobilized and elevated. This phase is preceded by a curettage, primarily to rule out endometrial carcinoma but also to enlarge the cervical canal.

After completion of the anterior dissection the next phase of the operation is amputation of the cervix The incision in the mucosa is carried around the cervix, and the mucosa is dissected from the cervix posteriorly to a level above that of the proposed amputation. Gauze dissection is useful in this step. The cardinal ligament is then exposed on each side of the cervix, grasped close to the cervix with an Ochsner clamp, cut, and ligated with a No. 1 chromic catgut suture. The cervix is then amputated (Figs 1121 and 1122). The flap of mucosa posterior to the cervix is then drawn onto the posterior part of the cervical stump, using a modified Sturmdorf suture with No 1 chromic catgut on a trocar needle (Fig. 1123).

Two steps in sequence constitute the next phase of the operation. In the first step interrupted sutures of 00 chromic catgut are used to plicate the musculofascial tissue under the bladder as described in the operation for repair of cystocele. In the second step interrupted sutures of No 1 chromic catgut are used to suture the cardinal ligaments together anterior to the uterus. These sutures include the anterior part of the uterus (Fig 1124). The upper of these sutures include the bladder "pillars" which lower fuse with the cardinal ligaments The sutures at the bladder level are tied first; then the sutures in the cardinal ligaments are tied (Fig 1125) Tying these sutures approximates the bladder pillar and cardinal ligament on one side to their fellows on the other, thus maintaining the bladder in its advanced position on the uterus, and elevating the latter.

A modification of the above method of handling the cardinal ligaments is to free their cut ends and suture the latter together anterior to the uterus.

The redundant vaginal mucosa is then excised. The wound is then closed with interrupted sutures of No. 1 chromic catgut (Fig. 1127), a modified Sturmdorf suture being used to bring the vaginal mucosa over the anterior part of the cervix (Fig. 1126).

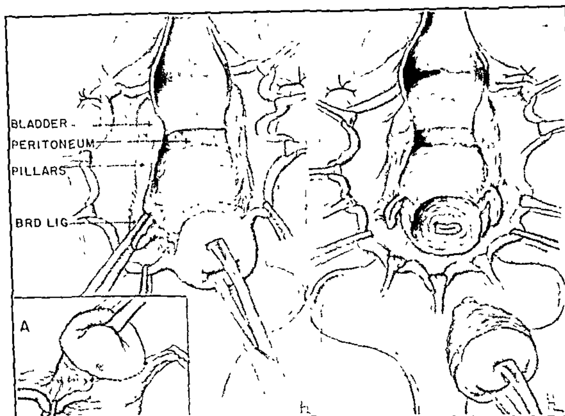



Fig. 1121. Fig. 1122.

Fig 1121.—Manchester operation The anterior vaginal wall has been dissected and the bladder has been elevated Traction causes the bladder pillars to stand out. Inset *A*, The circumcision posteriorly.

Fig. 1122 —Manchester operation The mucosa has been mobilized freely about the cervix. Each cardinal ligament, including the cervical branches of the uterine vessels, has been clamped, cut close to the cervix, and ligated. The cervix has then been amputated along the dotted line shown in the preceding figure.

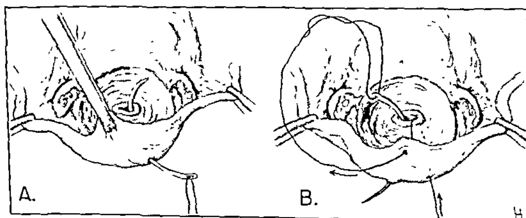



Fig 1123.—Manchester operation. A modified Sturmdorf suture, with No 1 chromic catgut on a trocar needle, is used to draw the posterior mucosal flap over the posterior part of the cervical stump.

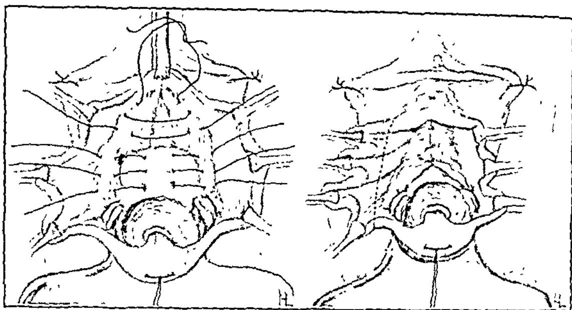


Fig. 1124. Fig. 1125.

Fig. 1124.—Manchester operation. Sutures have been placed in the perivesical tissues. Then sutures have been placed *in the bladder pillars and parametrial tissues including the* cardinal ligaments. Each of the latter sutures includes a bite of the cervix.

Fig. 1125.—Manchester operation. Sutures have been tied. The floor under the bladder has been reconstructed, the bladder advanced on the uterus, and the corpus elevated and brought forward. The cardinal ligaments may be brought closer together than illustrated and in some cases are actually sutured together.

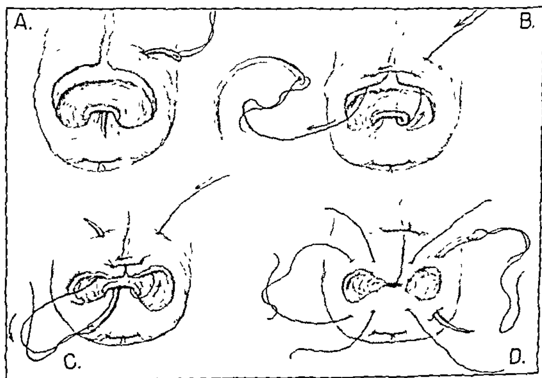



Fig 1126.—Manchester operation. Redundant vaginal mucosa has been excised. The posterior Sturmdorf suture has been tied. In *A*, *B*, and *C*, a modified Sturmdorf suture is *being placed in covering the cervical stump anteriorly.* In *D*, lateral sutures are being taken to complete the covering of the cervical stump.

As the final phase a colpoperineorrhaphy is done. Then a gauze pack is placed in the vagina for twenty-four hours, and an indwelling Foley catheter is used for three to five days. The patient is usually permitted to be out of bed on the first or second postoperative day.

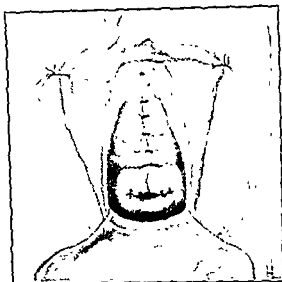


Fig. 1127.—Manchester operation. All mucosal margins have been approximated with interrupted sutures. The operation is complete except for a colpoperineorrhaphy.

## VAGINAL HYSTERECTOMY

Vaginal hysterectomy has become an established method of treating prolapse of the uterus. C. H. Mayo was one of the first to popularize this method, and there have been many modifications or substitute technics developed since. As previously stated, we generally employ vaginal hysterectomy in cases of complete prolapse of the uterus, and also in cases of incomplete prolapse of a diseased uterus. Abdominal hysterectomy is preferred for the removal of the nonprolapsed uterus.

### Technic of Vaginal Hysterectomy

The patient is prepared as described for other vaginal operations. The uterus is curetted. The anterior vaginal wall and bladder are dissected as described for the correction of cystocele and as for the Manchester operation (Fig. 1128). The exposed vesicouterine fold of peritoneum is then incised (Fig. 1129), or its incision may be postponed until after the rectouterine fossa has been opened. Circumcision of the cervix is then completed, the mucosa is stripped back, and the posterior peritoneal reflexion is incised close to the cervix, opening the rectouterine fossa (Figs. 1130 and 1131). If the peritoneum has not been opened anterior to the uterus already, its opening may be facilitated by running a finger through the rectouterine fossa over the uterus or broad ligamer [illegible]
peritoneum of the latter over the finge [illegible]
are exposed and clamped close to the cervix with Ochsner clamps (Figs. 1132 and 1133). The clamps on the cardinal ligament include the uterine vessels. Though not shown in the illustrations, usually two clamps are placed parallel on each of the ligaments and the ligaments are cut between them However, in some cases it is possible to clamp off the entire blood supply to the uterus before cutting; in such

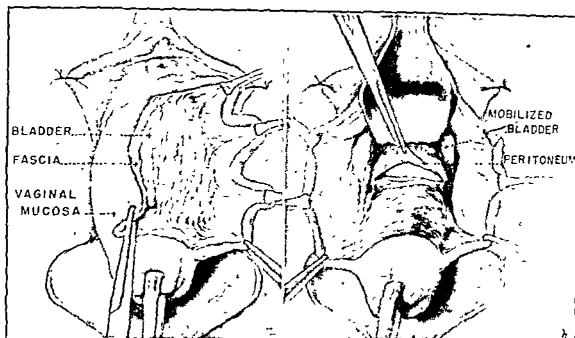



Fig. 1128. Fig. 1129.

Fig. 1128.—Vaginal hysterectomy. The anterior vaginal wall has been opened and partly dissected.

Fig. 1129.—Vaginal hysterectomy. The bladder has been mobilized and is retracted anteriorly. The vesicouterine reflection of peritoneum has been incised.

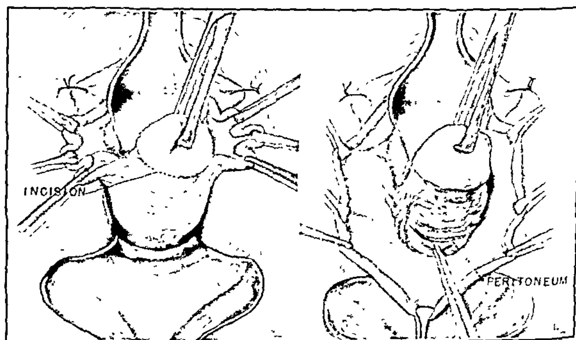
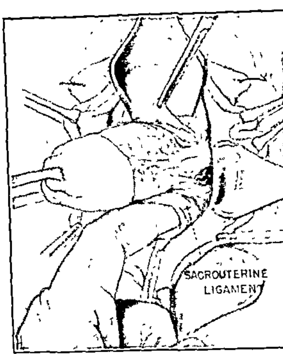



Fig 1130 Fig 1131.

Fig 1130.—Vaginal hysterectomy The cervix is drawn forward and the line for completion of the cervical circumcision is shown

Fig. 1131.—Vaginal hysterectomy. The peritoneum of the rectouterine fossa has been incised close to the cervix



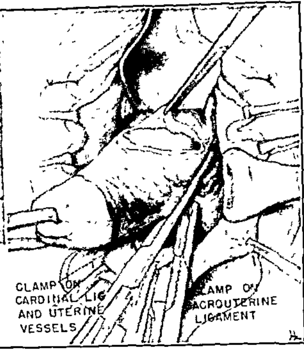




Fig 1132 Fig. 1133.

Fig 1132.—Vaginal hysterectomy. The *left parametrial tissues* are exposed and the finger is inserted posterior to the uterosacral ligament. The uterine vessels are seen in and near the cardinal ligament.

Fig. 1133—Vaginal hysterectomy. An Ochsner clamp has been placed on the left uterosacral ligament and another on the left *cardinal ligament*. The latter clamp includes the uterine vessels. Both clamps are placed close to the uterus. The uterosacral ligament has been cut medial to the clamp

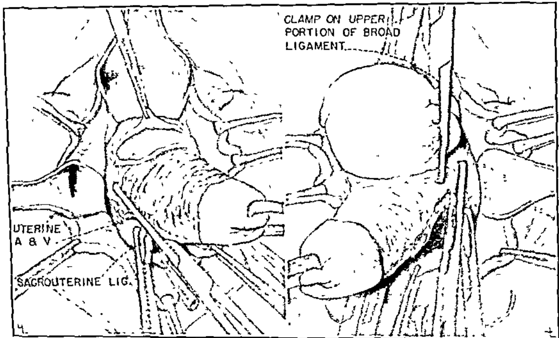



Fig. 1134. Fig. 1135.

Fig. 1134.—Vaginal hysterectomy. Clamps have been placed on the right side, and the right uterosacral ligament has been cut.

Fig. 1135—Vaginal hysterectomy. The corpus has been drawn through the anterior peritoneal opening. An Ochsner clamp has been placed *from above across the left broad ligament*, including the round ligament, tube, and associated vessels. The right broad ligament will be clamped. Cutting medial to these clamps will remove the uterus.

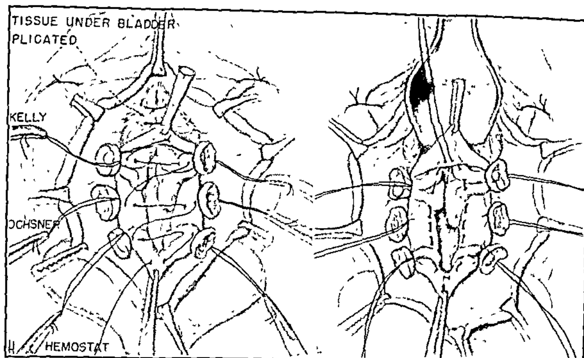



Fig. 1136. Fig. 1137.

Fig. 1136.—Vaginal hysterectomy. The tissues have been ligated and the ligatures clamped for identification. The subvesical tissues are plicated. The peritoneum is closed with a running suture

Fig 1137.—Vaginal hysterectomy. Alternate method of closing the peritoneum with a purse string if the opening is sufficiently small.

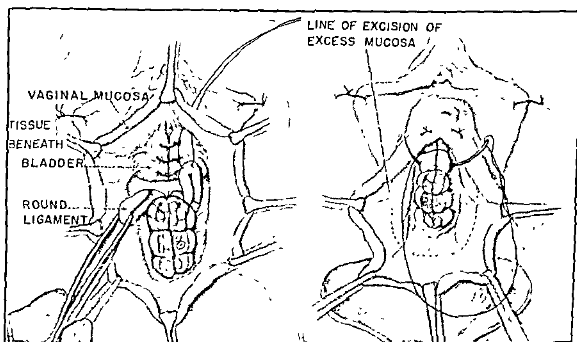



Fig 1138 Fig. 1139.

Fig. 1138.—Vaginal hysterectomy. The subvesical tissue is plicated On each side a suture is taken in the round ligament a short distance from its ligated pedicle, passed through the vaginal mucosa and other tissues subjacent to the pubic ramus, and both are tied.

Fig. 1139.—Vaginal hysterectomy. A running lockstitch unites the round ligaments posterior to the foregoing sutures It is to continue onto the broad ligament and uterosacral pedicles, further approximating them. The suture passes external to the ligatures on the pedicles.

cases it is not necessary to have clamps on the uterine side of the ligaments when they are cut. When a large piece of tissue is clamped, it is advisable to use an additional clamp, a small one, which holds a bit of the proximal tissue on the medial side of the large one to keep this tissue, when cut, from slipping through the large clamp.

After the uterosacral and cardinal ligaments have been secured on one side, the same may be done on the other side (Fig. 1134), or the uterine body may be drawn through the anterior peritoneal opening and the rest of the broad ligament clamped (Fig. 1135). The latter clamp or clamps include the tube, the round ligament, the ovarian ligament, and the blood vessels of that area. This portion of the broad ligament is cut now or after the other side has been similarly treated; and, when clamping and cutting is complete on both sides, the uterus is removed. The adnexa are then investigated, and removed only if specially indicated.

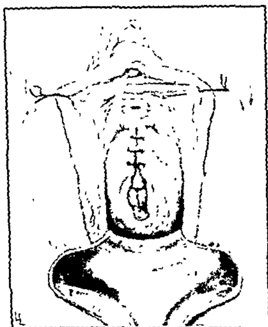


Fig 1140—Vaginal hysterectomy. Excessive vaginal mucosa has been excised along the dotted line in the previous illustration, and the mucosal wound is being closed with interrupted sutures

At this point there are usually three clamps on each side, on the broad ligament and associated structures. The tissue in each of these clamps is securely ligated with No 1 chromic catgut and the ends of the ligature are left long. For identification small hemostats are placed on the suture ends from the uterosacral ligaments, Ochsner clamps on those from the cardinal ligaments, and Kelly clamps on those from the rest of the broad ligaments (Fig 1136).

Before closing the peritoneal opening, the musculofascial tissues under the bladder are plicated with interrupted sutures of 00 chromic catgut as in the repair of a cystocele, and any redundant peritoneum at the posterior angle of the peritoneal wound is excised. If an enterocele is present, it is corrected. Closure of the peritoneum is done with a running suture of No. 1 chromic catgut if the opening is large (Fig. 1136) This suture starts in the peritoneal reflexion from the bladder, then runs back and forth between the peritoneum of the broad ligaments, includes the uterosacral ligaments, and ends posteriorly in the peritoneum on the anterior sur-

face of the rectum. The bites in the peritoneum must be superficial to avoid injury to vessels. An alternate method, if the peritoneal opening is small, is to close it with similar material placed as a purse string between the same structures (Fig. 1137).

A suture of No 1 chromic catgut is then taken in the round ligament on each side, a short distance from its ligated pedicle. These sutures are passed through the vaginal mucosa and subjacent tissues near the pubic rami and tied, drawing these ligaments forward beneath the bladder, and tending to shift the other broad ligament structures anteriorly (Figs. 1138 and 1139).

A running lockstitch of No. 1 chromic catgut unites in the midline the round ligaments distal (posterior) to the foregoing sutures. This stitch is continued posteriorly onto the pedicles of the broad ligaments (Fig. 1139). The suture passes external to the ligatures, to avoid puncturing vessels, and further unites the broad ligament structures in the midline. The suture ends by approximating the uterosacral ligaments.

Redundant vaginal wall is then excised, and its cut edges are approximated with interrupted sutures (Fig. 1140) or a continuous lockstitch of No. 1 chromic catgut. The former are less likely to shorten the vagina.

These patients require a colpoperineorrhaphy. This may be done before or after the anterior vaginal wall is closed. Continuation of the anterior incision onto the posterior vaginal wall may facilitate the posterior dissection in some cases, but this union of the two wounds as the vaginal vault is probably more apt to produce vaginal shortening and lead to dyspareunia.

At the end of the operation a pack is placed in the vagina for twenty-four hours and a Foley catheter in the bladder for three to five days. The patient is allowed out of bed on the first or second postoperative day.

## *THE SPALDING-RICHARDSON COMPOSITE OPERATION*

This operation was developed independently by Spalding and by Richardson In its essentials it consists of amputation of the cervix, supravaginal hysterectomy, subvesical transposition of the remaining segment of uterus, and repair of the vaginal wall. TeLinde prefers this operation to total vaginal hysterectomy in the treatment of prolapse in selected cases, and believes that better results with the composite operation are obtained because the cardinal and uterosacral ligaments remain attached to the uterine remnant with their blood supply intact.

## WATKINS INTERPOSITION OPERATION

In 1898 Watkins first performed an operation for the correction of cystocele and uterine prolapse in which the uterine body is interposed between the bladder and the anterior vaginal wall This operation has been widely used in selected cases It is contraindicated when the uterus is diseased; and the possibility of pregnancy must be eliminated. The consensus seems to be that it should not be used in young women, and preferably should be used only in those women in or past the menopause. *Its chief indication is incomplete prolapse of a normal-sized, healthy uterus, associated with a large cystocele, in an older woman.*

We have had very limited experience in performing this operation, and we have operated upon women for recurrence of prolapse and cystocele who have pre-

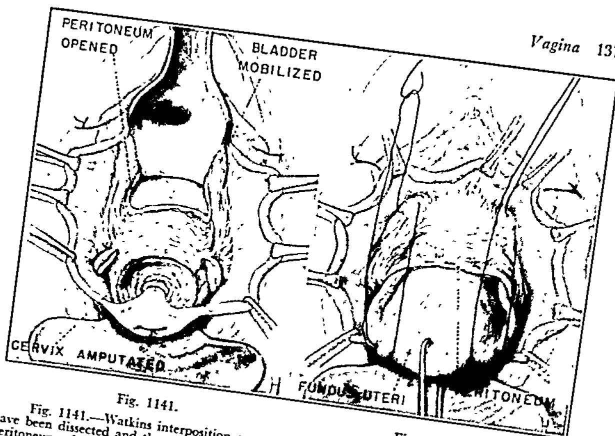



Fig. 1141.

Fig. 1142.

Fig. 1141.—Watkins interposition operation. The anterior vaginal wall and the bladder have been dissected and the cervix has been amputated, as in the Manchester operation. The peritoneum of the vesicouterine fold has been opened. A retractor has been inserted through this opening and is displacing the bladder forward.

Fig. 1142.—Watkins interposition operation. The corpus is drawn through the peritoneal opening. The peritoneal flap from the bladder is sutured to the posterior aspect of the uterus. Sutures are placed between the fundus and the tissues under the pubic rami and, when tied, will bring the corpus under the bladder.

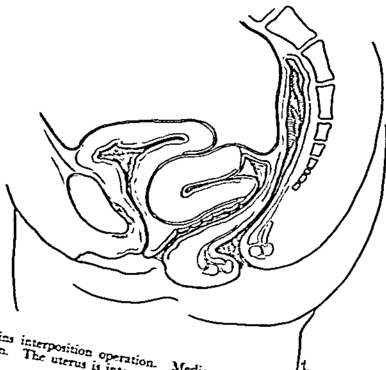


Fig. 1143.—Watkins interposition operation. Median sagittal section showing the completed operation. The uterus is interposed between the vagina and the bladder.

face of the rectum. The bites in the peritoneum must be superficial to avoid injury to vessels. An alternate method, if the peritoneal opening is small, is to close it with similar material placed as a purse string between the same structures (Fig. 1137).

A suture of No. 1 chromic catgut is then taken in the round ligament on each side, a short distance from its ligated pedicle. These sutures are passed through the vaginal mucosa and subjacent tissues near the pubic rami and tied, drawing these ligaments forward beneath the bladder, and tending to shift the other broad ligament structures anteriorly (Figs. 1138 and 1139).

A running lockstitch of No. 1 chromic catgut unites in the midline the round ligaments distal (posterior) to the foregoing sutures. This stitch is continued posteriorly onto the pedicles of the broad ligaments (Fig. 1139). The suture passes external to the ligatures, to avoid puncturing vessels, and further unites the broad ligament structures in the midline. The suture ends by approximating the uterosacral ligaments.

Redundant vaginal wall is then excised, and its cut edges are approximated with interrupted sutures (Fig. 1140) or a continuous lockstitch of No. 1 chromic catgut. The former are less likely to shorten the vagina.

These patients require a colpoperineorrhaphy. This may be done before or after the anterior vaginal wall is closed. Continuation of the anterior incision onto the posterior vaginal wall may facilitate the posterior dissection in some cases, but this union of the two wounds as the vaginal vault is probably more apt to produce vaginal shortening and lead to dyspareunia.

At the end of the operation a pack is placed in the vagina for twenty-four hours and a Foley catheter in the bladder for three to five days. The patient is allowed out of bed on the first or second postoperative day.

## THE SPALDING-RICHARDSON COMPOSITE OPERATION

This operation was developed independently by Spalding and by Richardson. In its essentials it consists of amputation of the cervix, supravaginal hysterectomy, subvesical transposition of the remaining segment of uterus, and repair of the vaginal wall TeLinde prefers this operation to total vaginal hysterectomy in the treatment of prolapse in selected cases, and believes that better results with the composite operation are obtained because the cardinal and uterosacral ligaments remain attached to the uterine remnant with their blood supply intact.

## WATKINS INTERPOSITION OPERATION

In 1898 Watkins first performed an operation for the correction of cystocele and uterine prolapse in which the uterine body is interposed between the bladder and the anterior vaginal wall This operation has been widely used in selected cases. It is contraindicated when the uterus is diseased; and the possibility of pregnancy must be eliminated. The consensus seems to be that it should not be used in young women, and preferably should be used only in those women in or past the menopause. *Its chief indication is incomplete prolapse of a normal-sized, healthy uterus, associated with a large cystocele, in an older woman.*

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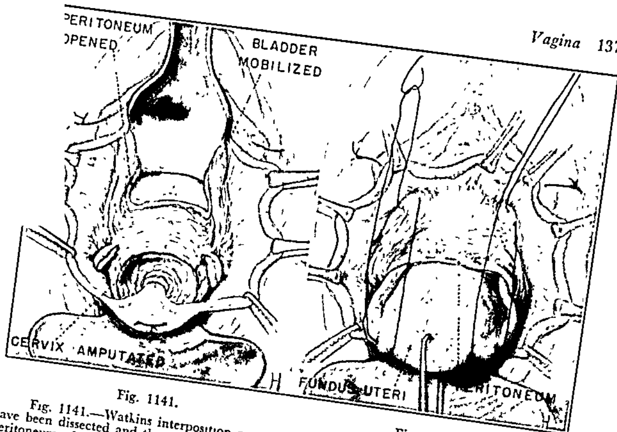



Fig. 1141.

Fig. 1142.

Fig. 1141.—Watkins interposition operation The anterior vaginal wall and the bladder have been dissected and the cervix has been amputated, as in the Manchester operation The peritoneum of the vesicouterine fold has been opened. A retractor has been inserted through this opening and is displacing the bladder forward.

Fig 1142.—Watkins interposition operation. The corpus is drawn through the peritoneal opening The peritoneal flap from the bladder is sutured to the posterior aspect of the uterus Sutures are placed between the fundus and the tissues under the pubic rami and, when tied, will bring the corpus under the bladder.

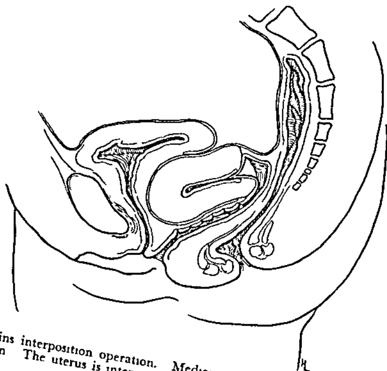


Fig 1143.—Watkins interposition operation. Median sagittal section showing the completed operation The uterus is interposed between the vagina and the bladder.

viously had this operation performed by others. Possibly influenced by thes facts, though perhaps not with justification, and considering the possibility of t trouble with the abnormally placed uterus, we have had no enthusiasm fo operation. Nevertheless we are impressed by favorable reports from some qu and believe that there may be a place for the operation in selected cases m the qualifications named above.

In the performance of the operation a curettage is done and then a diss of the anterior vaginal wall and bladder is performed, and the cervix is ampu all much as in the Manchester operation (Fig. 1141). However, the cardinal ments are not drawn anterior to the cervix. Instead the peritoneum is open the vesicouterine fold and the body of the uterus is drawn through this openin the patient is capable of pregnancy, the tubes are now resected. Then the toneal flap from the bladder is sutured to the posterior aspect of the uterus witl eral interrupted sutures of chromic catgut. Next the musculofascial layer the bladder may or may not be plicated This is not necessary unless the ute too small to support the bladder satisfactorily. Then the corpus is placed unde bladder, and No. 1 chromic catgut sutures are passed between the fundus an tissues under the pubic rami (Figs. 1142 and 1143). Excess vaginal mucosa cised. Then the vaginal wall is closed with interrupted No. 1 chromic catg tures which include the overlying anterior surface of the uterus The cervical s is covered with mucosa, using modified Sturmdorf sutures as in the Mancheste eration.

## LE FORT COLPOCLEISIS

In elderly very poor surgical risk patients in whom the sexual function nee be considered, partial or complete obliteration of the vagina is a simple, lo procedure, useful for the treatment of prolapse of the uterus or vagina. How in these days of advanced medical care and greatly improved adjuncts to sur there are few patients who need to have the correction of prolapse restricted to type of surgery.

The Le Fort partial closure is the type of colpocleisis usually employed I a curettage is done. Then a rectangular strip of mucosa is excised from the ant vaginal wall, its long axis extending from near the cervix to the introitus. A s lar strip is excised from the posterior wall. The two denuded areas are ther tured together. Interrupted No. 1 chromic catgut sutures are passed to unite mucosal margins of one rectangle to the corresponding margins of the other tangle, and a few sutures may be taken directly between the denuded areas th selves. Thus, the vagina is closed except for a transverse channel just distal to cervix and a longitudinal channel on each side of the vagina These channels to permit drainage The addition of a perineorrhaphy improves the result.

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# CHAPTER 78

# THE UTERINE CERVIX

## CURETTAGE AND OPERATIONS FOR BENIGN LESIONS

RANDOLPH H. HOGE

## DILATATION OF THE CERVIX

Dilatation of the cervix is indicated in true stenosis of the cervix, in a number of other conditions, and as a preliminary step in curettage of the uterus. The most common cause of stenosis of the cervix is some treatment, surgical or otherwise, of the cervix. Stenosis should be suspected in patients with certain menstrual disturbances who have had such treatment. It is capable of causing dysmenorrhea but not of the primary type. We have little faith in cervical dilatation in the treatment of primary dysmenorrhea and are opposed to the use of intrauterine pessaries in this condition; but dilation may be done in some cases of primary dysmenorrhea to rule out stenosis.

The technic is as follows: The anterior cervical lip is grasped firmly with a tenaculum, and a uterine sound or, if necessary, a small surgical probe, or a small Hegar dilator is inserted to determine the presence, location, extent of the stenosis, and the position of the corpus Care must be taken not to penetrate the uterine wall, and a knowledge of the position of the corpus will aid in preventing perforation. Following sounding of the uterus dilators are used, either the Hegar type dilators in graduated sizes, or the Goodell dilator, or both (Fig. 1144). The dilators are inserted with their curves corresponding to the position of the corpus. The extent of dilatation will vary according to the indication and to the condition of the cervix. In the treatment of stenosis dilatation is usually considerable. In elderly women with atrophic cervices, and also in the presence of carcinoma, laceration is easy, and for this reason dilatation in these cases should be limited If, on probing or dilating the cervix, retained blood or pus is found, cancer must be considered In the case of hematometra, cautious curettage should be done; in the case of pyometra, curettage should be deferred until the infection has subsided

## CURETTAGE OF THE UTERUS

Dilatation of the cervix is the initial step in curettage of the uterus. For this reason, and because curettage is so frequently combined with other operations on the cervix, it is discussed in this chapter.

The reason for curettage may be diagnostic or therapeutic. Curettage is indicated for investigation and diagnosis in cases of functional bleeding, sterility, complications of pregnancy, carcinoma, and other disturbances, and it is often of thera-

peutic value in many of these conditions. Sometimes, as in cases of endometrial polyps or incomplete abortion, it may be curative. Furthermore, curettage may be done routinely during the course of certain other operations, e.g., Manchester repair, to rule out carcinoma or other intrauterine disease, even in the absence of significant symptoms.

The technic is as follows: After the uterus has been sounded and the cervix dilated, a piece of muslin or similar material is placed on the posterior wall of the vagina and tucked into the posterior fornix to catch the blood and curettings (Fig. 1145). A uterine curette is selected from a set of several sizes and the entire uterine cavity is curetted in an orderly fashion, covering both anterior and posterior walls with overlapping longitudinal strokes and the true fundus with transverse strokes (Fig. 1146). *In most cases a sharp curette is used, but in pregnancy and in some cases of carcinoma invading the myometrium a sharp curette is dangerous and a dull one should be used.* Great care must be taken in both of these conditions to avoid perforation of the uterus. When one is interested only in the phase of the endometrium, it is not necessary to scrape the entire cavity. If the curette brings forth tissue which is obviously carcinomatous, it is unnecessary and in fact undesirable to curette further. Packing of the uterus or the vagina is rarely indicated.

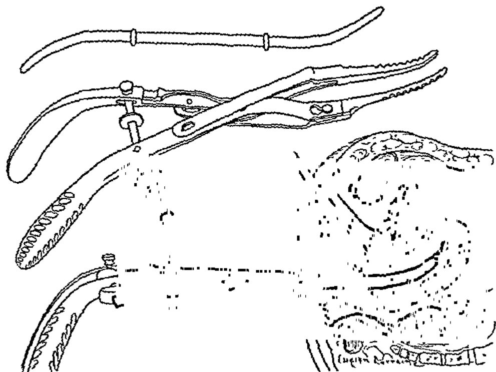


Fig. 1144—Dilatation of the cervix. A Goodell dilator and one of a set of graduated dilators are illustrated. A weighted speculum is shown over the perineum and posterior vaginal wall. The anterior lip of the cervix has been grasped with a tenaculum and a Goodell dilator is inserted.

If during this operation the uterus is perforated, the operation should be halted and the patient carefully observed for signs of internal hemorrhage or infection, and antibiotics should be administered. *Perforation is not usually a serious complication*, and laparotomy solely because of this complication is not indicated unless there is evidence of significant internal bleeding, shock, or perforation of a hollow viscus. Evidence of these calls for immediate laparotomy.

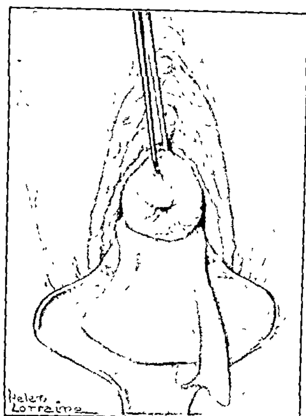



Fig. 1145 —Curettage. Th
A piece of muslin

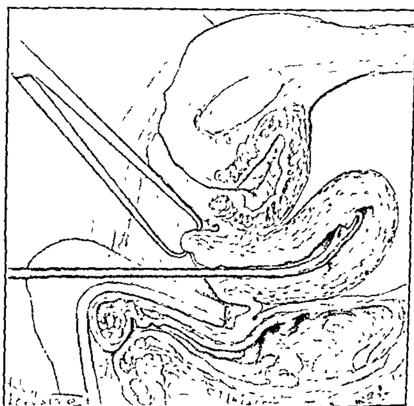


Fig. 1146 —Curettage. Traction is exerted on the anterior lip of the cervix and the endometrium is curetted.

## BIOPSY OF THE CERVIX

Any lesion of the cervix not obviously benign should be biopsied, and any tissue removed from the cervix during the course of an operation should be examined microscopically. Tissue for biopsy should be adequate in amount and should come preferably from the margin of a lesion, including a portion of the healthy surrounding tissue. Necrotic tissue should be avoided. The tissue may be removed with the scalpel, scissors, special forceps, or with the electrosurgical loop. It should not be traumatized or burned. Bleeding is not usually troublesome, but if present it may be controlled by cauterization, coagulation, suturing, the application of hemostatic substances, or by simple pressure.

## TREATMENT OF EROSIONS, POLYPS, CYSTS, AND CHRONIC INFECTIONS OF THE CERVIX

Common benign lesions of the cervix requiring treatment include polyps, cysts, and infections The methods of treating these lesions date back to ancient times. Polyps may be excised with scissors, scalpel, the cautery, the electrosurgical knife, or a tonsil snare. Prolapsed submucous fibroids may be treated similarly. One of the most useful methods is to grasp the polyp with a sponge forceps or a clamp and twist it off In most cases it is not necessary to do anything further to secure hemostasis, but ligating, suturing, or cauterizing the pedicle is desirable or necessary in some cases. Recurrences may call for cautery treatment of the site of recurrence or for conization. In most instances the treatment of a polyp is an office procedure and no anesthesia is necessary. These tumors, though rarely malignant, should be examined microscopically Furthermore, it is well to bear in mind that the polyp in any particular case is not necessarily the cause of the abnormal bleeding. Therefore, the patient should have a thorough curettage at the time of the removal of the polyp if she is anesthetized and hospitalized, and, if not, she should be carefully observed for future abnormal bleeding.

Single cysts can be destroyed with the actual cautery or be electrocoagulated. Most uncomplicated superficial benign lesions of the cervical mucosa, such as true erosions and pseudo-erosions, can be satisfactorily treated with the nasal tip cautery lightly applied, or with superficial electrocoagulation. However, most chronic inflammatory lesions of the cervix are not confined to the surface but involve the deeper tissues and the cervical glands. These more common and deeper lesions are best treated by methods which remove intact and at once all the diseased area, rather than by deep cauterization or coagulation, which leave a foul slough to separate, produce nothing for microscopic examination, and, in the view of some, probably lead more to postoperative hemorrhage, scar tissue, and stenosis.

## STURMDORF TRACHELOPLASTY

The most satisfactory purely surgical (as opposed to electrosurgical) means of treating chronic cervicitis is the operation devised by Sturmdorf and reported in 1915. He pointed out the shortcomings of the prevailing operations of his day. For example, Emmet's trachelorrhaphy was little more than the plastic closure of a gap and overlooked the fact that the important lesion was the infection that resulted from a laceration and not the laceration itself Emmet's operation did not remove

all the infected tissue and also was unnecessarily incomplete prophylaxis against cancer. Furthermore, in the cervical amputations of the day, granulation tissue almost invariably resulted, leading to infection and annular scarring, and often to dystocia. Sturmdorf felt that his operation, though not resulting in ideal restitution to the normal in all cases, obviated in the greatest number of cases these and other drawbacks, in that, among other things, it completely extirpated the diseased cervical mucosa, preserved much of the cervical musculature, and secured sutural coaptation of the mucosal flap to the stump.

A slightly modified technic of the Sturmdorf tracheloplasty which we occasionally use is as follows:

The cervix is grasped with a tenaculum and a circular incision is made through the cervical mucosa on the vaginal surface external to the diseased area. The mucosa external to this incision is mobilized to a circular line at or near the level of the internal os, thus forming a circular flap about the cervix. Then a cone of cervix, including all diseased tissue, is excised with a scalpel. The base of the cone lies about the external os and the apex reaches the internal os. The removal of the cone leaves a raw funnel-shaped cavity. The surface of this cavity is then covered with the circular flap of mucosa already developed. To accomplish this, sutures of No. 1 chromic catgut on a trocar needle are used in the following manner: Traction is exerted on the anterior part of the mucosa flap. The needle is inserted through the base of the flap about 3 to 4 mm. to the right of the midline and carried through the cervix into the cervical canal at the apex of the funnel The stitch is brought out here and the needle is then inserted from without inward through the anterior mucosal flap at a point 3 to 5 mm. upward from the midpoint of the free margin of the flap. The needle is then passed back to the cervical canal at the apex of the coned area and brought out through the cervical tissue and the anterior part of the vaginal flap at the latter's base 3 to 4 mm. to the left of the midline. In passing this suture care must be exercised not to injure the bladder, which may be separated from the cervix and the flap if necessary. The ends of the suture are now drawn tight and tied, pulling the flap into the anterior half of the cavity. Then the same type of suture is placed posteriorly. If there is any gaping of the mucosal margins laterally, simple catgut sutures may be taken to approximate the margins here. The suturing in this operation is illustrated with modifications in the portion of the text dealing with the Manchester operation

## AMPUTATION OF THE CERVIX

The Sturmdorf method with appropriate modifications is useful in doing amputations of the cervix In such amputations the mucosal incision is higher, the mucosal flap is dissected higher, the cervical branches of the uterine vessels are ligated with sutures, the cervix is cut across at a higher level with or without leaving a funnel-shaped cavity, and the mucosal flaps are brought in the same way, using the same type of sutures. Such amputations are frequently done in association with vaginal repair, and the method is illustrated in the portion of this text dealing with the Manchester operation.

## CONIZATION

Deep cauterization, trachelorrhaphy, Sturmdorf tracheloplasty, and amputation of the cervix in the treatment of chronic cervicitis have been replaced to a con-

siderable extent by conization, though there are some who use this method rarely or not at all. The method was devised by Hyams, who first published a description of it in 1928. It involves an active electrode in the cervix, using a cutting current from a high frequency electrical machine. Hyams' electrode consisted in part of a slightly curved tungsten wire projecting 3 mm. from a silicon tube in such a manner that when the instrument was rotated in the cervical canal the lining membrane of the canal would be removed. Since the introduction of this method, others have modified it. Crossen has changed the electrode so that it has a triangular loop, the base of which extends a considerable distance from the axis. In use, this modified electrode removes a cone of cervical tissue similar to that removed in the Sturmdorf tracheloplasty. Crossen has adopted the use of Sturmdorf type sutures to turn in the coned lips though no mucosal flap is developed. For a number of years we have taken sutures laterally to approximate the coned anterior and posterior lips in an effort to hasten complete healing and decrease postoperative bleeding. Only in the very widest conization have we found that the rim about the funnel could be turned in satisfactorily with Sturmdorf type sutures.

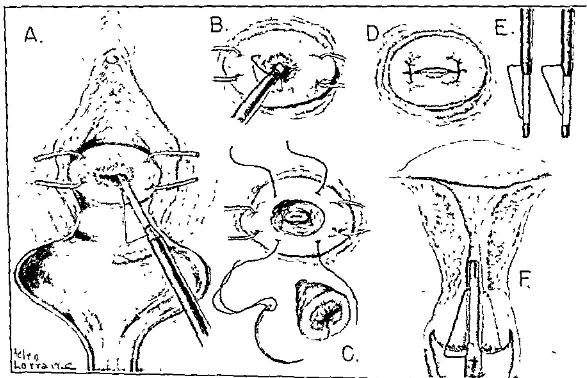



Fig. 1147.—Cervical conization *A*, Tenacula applied to cervix; electrode inserted. *B*, Electrode inserted to internal os, being rotated *C*, Cone of tissue removed In shallow conizations operation stops here; otherwise suture as shown here and in *D*. *E*, Crossen electrodes *F*, Section showing electrode in place and tissue to be removed

Conization can be performed in the office without anesthesia, but we believe that it is done more satisfactorily in the hospital under anesthesia The technic is as follows (Fig. 1147): The patient is in the lithotomy position, under intravenous Penthothal Sodium anesthesia, and localy prepared as for any vaginal operation. An inactive electrode has been placed under the sacral region well away from the operative site. A weighted speculum retracts the posterior vaginal wall and an

assistant retracts the anterior vaginal wall with another speculum. A single-toothed tenaculum (bullet forceps) is applied to the outer portion of the cervix near its base in each lateral fornix, and the cervix is drawn toward the introitus. The use of two forceps so placed exposes the cervix well and holds it in such a position that a more uniform conization can be done. A single forceps attached to the anterior lip may lie in the path of the electrode and also may fail to elevate the posterior lip satisfactorily, so that too little of the latter may be removed. The anterior speculum is removed unless the anterior vaginal wall bulges over the cervix. The surgeon holds the tenaculum to his left with his left hand, and the assistant holds the one to the right. The surgeon holds the Crossen electrode in his right hand, inserts the tip of the electrode to the level of the internal os, and turns on the current with *the foot switch. He then rotates the electrode through 360 degrees in one continuous* movement, removing a cone of tissue. If only a shallow conization is done, the operation stops at this point without suturing. If a moderately wide conization is done, we then place No. 1 chromic sutures laterally, usually only one on each side, to approximate the anterior and posterior raw surfaces. These sutures are tied loosely in order to prevent them cutting out later, and an interval is left where the external os will be. If a very wide conization is done, modified Sturmdorf sutures may be used anteriorly and posteriorly, and sutures as above are placed laterally.

Bleeding points, especially if sutures are not used, may be lightly coagulated, but deep or extensive coagulation should be avoided.

Healing occurs within six weeks. Considerable discharge and bleeding sometimes occur during the period of healing It is generally considered wise to pass a sound into the uterus at intervals of about two weeks during this period in an effort to prevent stenosis All other trauma is avoided until healing is complete.

There is a difference of opinion regarding the effect of this procedure on conception, pregnancy, and labor. Some feel that there are no untoward results. Furthermore, the elimination of infection may aid in conception. However, it is probably wiser to do a conservative (shallow) conization if future pregnancy is probable, and to reserve the deeper conizations for those in whom pregnancy is unlikely. Conization is of value when combined with supravaginal hysterectomy in cases in which total hysterectomy is contraindicated.

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# CHAPTER 79

# THE UTERUS

## TREATMENT OF CARCINOMA OF THE CERVIX; TREATMENT OF CARCINOMA OF THE ENDOMETRIUM

RANDOLPH H. HOGE

## CARCINOMA OF THE CERVIX

### History of the Surgical Treatment

In the beginning of the era of modern medicine, surgery was the only treatment of value for carcinoma of the cervix. The earliest operations were cervical amputation and vaginal hysterectomy. It is said that the first vaginal hysterectomy for carcinoma of the cervix was performed in 1822, and that it was not until 1878 that the first abdominal total hysterectomy was done for this condition. However, because of the much greater operative mortality of the abdominal operation, the vaginal operation was the procedure of choice for many subsequent years. Nevertheless, both of these procedures were inadequate and the cure rate was very low. The technic for both operations underwent a period of development which culminated in much more radical procedures aimed at the removal of carcinoma cells more distant from the uterus.

Many workers contributed to the development of the radical abdominal operation. Among them was Wertheim, who did most to publicize the operation. It was in 1900 that he reported 29 cases of the radical abdominal operation. In this report he described the total removal of the uterus, the adnexa, the parametrium, and the removal of variable amounts of the vaginal and pelvic lymph nodes. In some cases a portion of a ureter was removed. Though he used the abdominal approach, the dissected organs were removed from below. In 1911 Wertheim gave an additional report, publishing the results obtained in a series of 500 cases in which the abdominal operation was used in the treatment of carcinma of the cervix. The operative technic varied somewhat. In some cases the organs were removed from below as in his previous report. The regional lymph nodes were removed if enlarged.

Influenced by Wertheim's work, the radical abdominal operation has in general been designated by his name. However, the term is at times loosely used. Some of the operations so designated are of less magnitude than Wertheim's own; some are of greater magnitude than his.

The perfected radical vaginal hysterectomy, in which there was a wide excision of the parametrium, became known as the Schauta operation, after one of the work-

ers responsible for its development. These workers felt that the lower opera mortality of the vaginal approach overbalanced the advantage, if any, of remc of the pelvic lymph nodes in the abdominal operation. However, the vaginal eration for carcinoma of the cervix is little used today.

The highly developed operations resulted in a considerable percentage of cu in the operable cases, but even in expert hands the operative mortality was hi The radical operation was unsuited to the average surgeon, and the nonradi hysterectomy, more suited to him, had little or no justifiable place in the treatm of this condition. The radical procedure offered hope to the patient previou without hope, and it richly deserved the important place it came to occupy. that time the surgical treatment was in its heyday.

## Treatment by Irradiation

The discovery of radium in 1898 was later to change the outlook. The biolo effect of this element was first noted in 1901 and soon thereafter the special ser tivity of tumors was noted. Around 1910 Wickham, Cheron, Fabre, Dominici, a Jacobs reported the treatment of carcinoma of the cervix with radium. Ke treated carcinoma of the cervix with radium for the first time in 1909 and report his subsequent results in 1915.

At first, radium was used for the treatment of the inoperable cases as a pall tive measure. However, unexpected cures were sometimes obtained, and in oth instances much improvement followed. Encouraged by such results, cases in t operable group were treated with radium, either alone or in combination with su gery. It soon became apparent to many workers that as good results could be o tained by irradiation alone as by operation, that a larger number of cases could treated by irradiation, and that the mortality was considerably less. And so, by t 1930's surgery had been almost abandoned in favor of irradiation.

In general, the development of irradiative therapy went through three perio of development as illustrated in Lacassagne's report in 1932 from the Institut c Radium de Paris: In the first period the methods and material for the local a plication of radium were defective, in the second period these defects had be corrected, and in the third period external irradiation was added.

The addition of external irradiation, now generally by x-ray, was an impo tant development. As early as 1902, 1905, and 1906 there were reports on the trea ment of carcinoma of the cervix by x-ray, but it was not until some years later, fo lowing technical improvements and a combination with radium therapy, that x-ra found its true place in the treatment of carcinoma of the cervix The combinatio of radium and x-ray therapy was brought about by the need to supplement the ra dium effect at a distance from the cervix. This is because rays from radium, ap plied in any practical way in or about the cervix, cannot be delivered in lethal dose to carcinoma cells more than 3 to 4 cm. distant from the cervix. The addition c the x-ray extends the distance of the lethal effect without harmful increase of th dosage at the cervix External roentgen therapy has now become generally adopte as an essential part of the irradiative treatment of carcinoma of the cervix. Ou patients receive 9,000 r of external irradiation according to the method describe by Arneson and Quimby. It is given over a period of three weeks prior to the ra dium therapy

## Technic of Radium Therapy

The technic of radium application was developed along several lines. The Paris technic seems to be in general the best method; reports by Arneson and others support this view. We will describe briefly this method as slightly modified and used by us. It follows the principle of a smaller dose of radium given continuously over a longer period of time. The applicators are a Curie colpostat and an intrauterine rubber capsule (Fig. 1148). The colpostat is used first. Fifteen milligrams of radium are placed in each of the three containers of the colpostat. The colpostat is

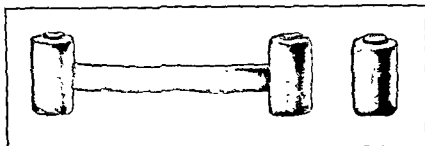


Fig. 1148.—Radium treatment of carcinoma of the cervix. The Curie colpostat.

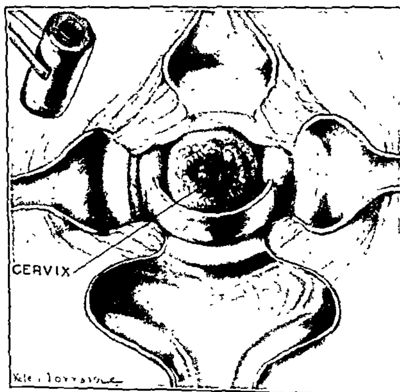



Fig. 1149.—Radium treatment of carcinoma of the cervix. The Curie colpostat is placed about the cervix.

placed in the vagina so that each of the two mounted containers is in a lateral fornix, and the third (loose) container rests against the cervix at the external os (Figs. 1149 and 1150). The colpostat is held in place by strips of gauze which also serve to displace the bladder and rectum as far as possible from the radium. The colpostat is left in (seventy-eight hours) until 3,500 milligram hours have been given. It is then removed, and the next day the intrauterine therapy is begun. For

this we usually use four platinum capsules, each containing 25 mg. of radium. They are tied in tandem in a rubber capsule and inserted into the uterine cavity so that no radium projects through the external os into the vagina (Figs. 1151 and 1152). The vagina is packed with gauze. The radium is left in the uterus until 3,500 milligram hours have been given. Thus, the patient receives a total of 7,000 milligram hours.

The filtration of the radium applicators is 0.5 to 1.0 mm. of platinum. The rubber containers used should contain no lead. As long as radium is in the patient, an indwelling catheter is used to prevent distention of the bladder and the foot of the bed is elevated in an attempt to keep as much as possible of the bowel out of the field of intense irradiation. We have found that soaking the vaginal pack with a mixture of the sulfonamides, zinc peroxide, and hydrogen peroxide lessens infection and odor. Intravenous Pentothal Sodium is the anesthesia generally used during the insertion of the radium. No anesthesia is used for its removal though a preliminary narcotic is advisable.

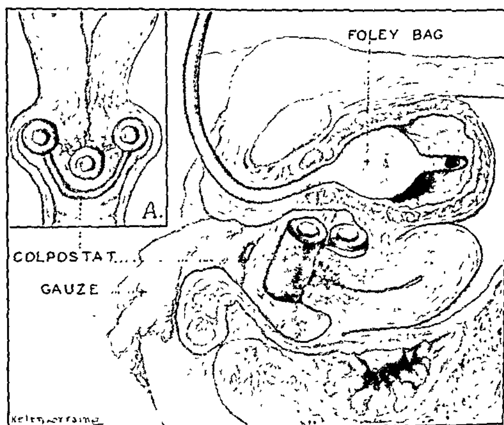



Fig. 1150.—Radium treatment of carcinoma of the cervix. The colpostat is in place about the cervix. The vagina is packed with gauze which supports the colpostat and displaces the bladder and the rectum away from the radium. *A*, Foley catheter is in the bladder.

This, as described, is the full course of radium treatment, and additional radium treatment is not intended. It should be borne in mind that each case in considered individually and modifications of the technic and dosage are often indicated. For example, a contracted vagina may necessitate the use of only a portion of the colpostat, or the absence of the uterine body may necessitate the use of interstitial radium to supplement that in the colpostat and in the cervical canal. In either of these examples the dosage should be reduced. Other local or general conditions may also modify the treatment

## Reawakening of Interest in the Surgical Treatment

*Throughout* the period when the consensus was overwhelmingly in favor of treatment by irradiation, there were a few who advocated the surgical treatment either alone or in combination with irradiation. Recently, in addition, one has noted a reawakening of interest in the surgical treatment. This interest has been brought about by a number of factors. On the one hand, there has been the failure

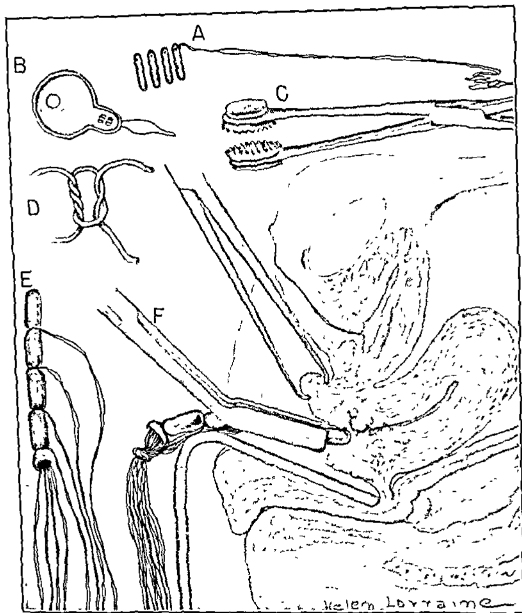



Fig. 1151.—Intrauterine radium. *A*, Platinum capsules of radium. *B*, Needle threader. *C*, Rubber-shod clamp for handling radium *E*, Rubber capsule in which the threaded radium units are in tandem. Thread, *using* knot (*D*), is tied between units to prevent overlapping. *F*, Instrument for inserting tandem.

of irradiation to eliminate carcinoma in the regional glands and to produce as many cures as had been hoped for. On the other hand, there are the recent advances in the adjuncts to surgery which tend to decrease the morbidity and mortality in radical surgical procedures.

Because of the apparent resistance to irradiation of carcinoma in the pelvic lymph glands, Taussig recommended transabdominal iliac lymphadenectomy in con-

junction with irradiation in stage II cases. Meigs has recommended radical terectomy in selected cases, and in other selected cases he and Nathanson have iliac lymphadenectomy through an extraperitoneal approach. Bonney for has continued to advocate radical surgery whenever possible. Brunschwig advo the surgical treatment of carcinoma of the cervix; and he has reported the exc of all the pelvic viscera in a series of cases of advanced stages of this disease.

At the Medical College of Virginia irradiation is used in almost all cases. cases of stages I and II the Taussig operation is added when the cervix has he following irradiation, and if the patient is a good operative risk. If, on entering abdomen to do the Taussig operation, conditions seem good for a radical hyst tomy, we have on rare occasion done the latter. We believe that radical su alone is justifiable in early stage I carcinoma of a low degree of malignancy in tients who are excellent operative risks, but even in these cases we have prefe irradiation alone and, more recently, irradiation with iliac lymphadenectomy. do not exclude iliac gland dissections in Stage I cases, because the glands ma carcinomatous even though grossly the lesion seems confined to the cervix.

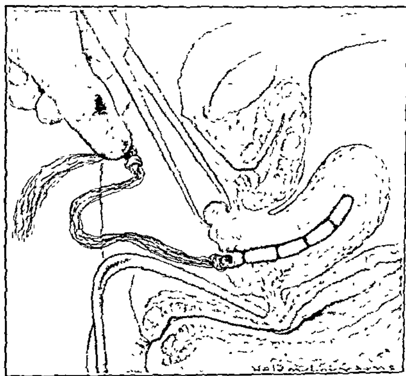


Fig 1152—Intrauterine radium The tandem has been inserted into the uterus All thr are left long and are brought out and fastened to the thigh with adhesive tape.

## Technic of Iliac Lymphadenectomy

A left lower paramedian incision is preferable Conditions in the pelvis investigated, and the liver and the region of the aortic nodes are palpated If th are no distant metastases, the ovarian vessels on one side are clamped, cut, ligated with No 1 chromic catgut at the lateral end of the infundibulopelvic li ment. Next, a salpingo-oophorectomy is done with a wide excision of the imme ately adjacent tissues of the broad ligament Then the peritoneal leaves of this ament are widely separated and may be held apart with large Kelly clamps (F 1153) The contents of the broad ligament and the structures on the pelvic w

are inspected and palpated. The bifurcation of the common iliac artery is identified. If there are no enlarged glands found proximal or distal to this bifurcation, dissection is begun just proximal to the bifurcation and extended distally. A gland at about the point of bifurcation of the common iliac artery is commonly found enlarged. All of the areolar, fatty, and lymphatic tissues about the common iliac bifurcation and about the external iliac and hypogastric branches of the common iliac vessels are to be excised (Fig. 1154). This is done as follows: The anterior part of the dissection is carried distally to the inguinal ligament in most instances In the course of the dissection the hypogastric vessels and certain of their branches are exposed and cleaned. Posteriorly and medially the ureter is identified, usually attached to the undersurface of the peritoneum of the posterior flap as this flap is retracted It forms the posteromedial border of the area of dissection. The ureter is followed downward to the point where it passes deep to the uterine artery, and is not dissected free, care being taken not to injure it or its blood supply.

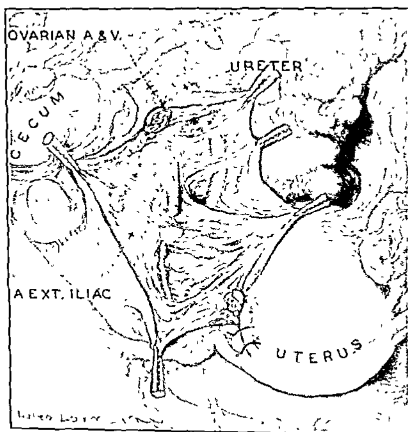



Fig 1153.—Iliac lymphadenectomy A salpingo-oophorectomy has been done. The peritoneal leaves of the broad ligament are widely separated, exposing the fatty and glandular tissues surrounding the vessels.

It is seen that the two diverging borders of the area being dissected are the external iliac vessels anterolaterally and the ureter posteromedially.

The dissection is carried distally between the two borders indicated above, and an attempt, usually not entirely successful, is made to remove in one piece all of the tissue to be excised (Fig. 1155). In the course of the dissection the obturator nerve is encountered. It is preserved. Associated with it and deeply placed behind the external iliac vein, one finds the obturator gland. It is one of the more commonly involved glands and is removed along with the other excised tissue. During the

dissection, the obliterated umbilical artery is found running more or less parallel with the obturator nerve and the ureter.

The dissection is usually stopped just short of the crossing of the ureter and the uterine artery, as here the difficulties and danger of the dissection are greatly increased and the tissues, being close to the cervix, have usually been adequately irradiated.

If, before the above dissection is begun, any of the glands described are found enlarged, the likelihood that the glands along the common iliac vessels are carcinomatous is increased. In this case the dissection is begun as high as the bifurcation of the aorta and carried down along the common iliac vessels to the bifurcation of these vessels. From this point the dissection proceeds as described above.

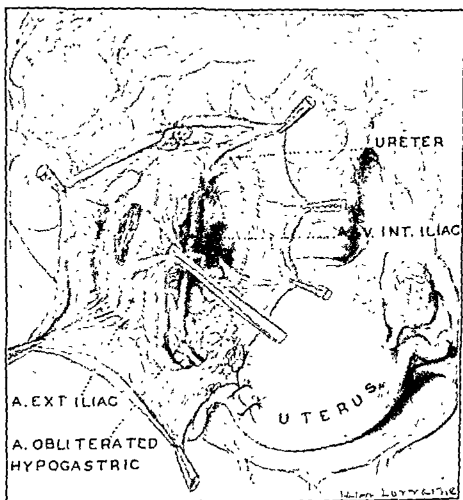



Fig. 1154.—Iliac lymphadenectomy. The lymphatic-bearing tissue is incised lateral to the external iliac artery The internal iliac vessels, the ureter, and the obliterated hypogastric artery are shown deep to the tissues to be excised.

The sacral glands are much less accessible and more rarely the site of metasases; they are not excised.

A similar procedure is done on the opposite side of the pelvis. The excision of lymphatic-bearing tissue having been completed on both sides, the broad ligaments are closed with running sutures of chromic catgut. In some instances preliminary suture of the round ligaments to the uterosacral ligaments at one point on each side is helpful (Fig. 1156).

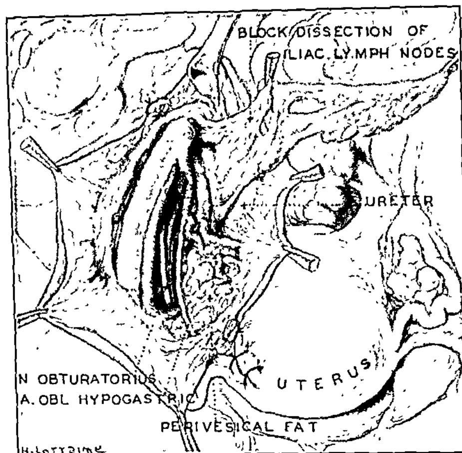



Fig. 1155—Iliac lymphadenectomy All of the gland-bearing tissue is removed. The following structures are exposed: bifurcation of the common iliac artery, external iliac artery, hypogastric artery and its branches, corresponding veins, the obturator nerve, the obliterated hypogastric artery, and the ureter.

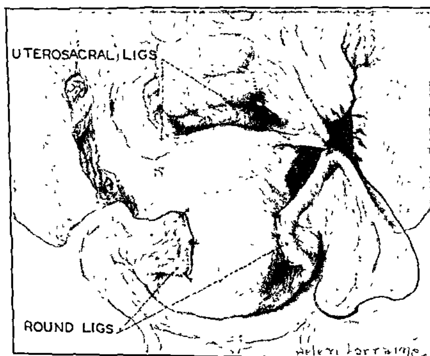



Fig. 1156.—Iliac lymphadenectomy. The round ligaments have been sutured onto the fundus of the uterus. The *left round* ligament has been sutured to the left uterosacral ligament. The left broad ligament is closed with a continuous suture.

## Radical Operation for Carcinoma of the Cervix

As has been previously brought out, radical hysterectomy is not at present the generally chosen treatment for carcinoma of the cervix. However, there are those who believe that there is a place for this treatment of this condition. One could not find fault with one who advocates radical surgery in a grade I, stage I, carcinoma of the cervix in a patient who is a good operative risk. But the hysterectomy, if selected, must be truly radical, not just an ordinary total hysterectomy with removal of the tubes and ovaries. It should consist of the removal of the uterus, tubes, ovaries, parametria, much of the uterosacral ligaments and the upper half of the vagina, all in one piece, and should also include the removal of the lymphatic tissues about the external iliac and the hypogastric vessels, about the obturator nerve, and occasionally about the common iliac vessels. In other words, if surgery alone is used as the treatment, the surgery should be a truly radical Wertheim operation plus the Taussig iliac lymphadenectomy; and, in the opinion of most surgeons, this operation should be done only in highly selected patients. This procedure involves, among other steps, the freeing of the bladder and rectum from the cervix and upper half of the vagina, and the dissection of the ureters from their bed to permit the removal of overlying and underlying structures.

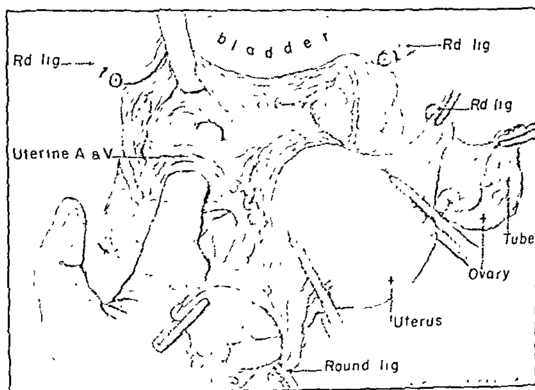



Fig. 1157.—Cervical carcinoma; radical operation. The uterus and adnexa are widely excised. The operator's finger, kept on the superior aspect of the ureter, is passed under the uterine vessels in the canal in which the ureter runs under these vessels to the bladder. The finger tip is brought out in the region of the vesical fascia.

A description of the technic of the operation follows: The vagina and the skin are prepared. A vaginal pack is not used and the ureters are not catheterized, but an open catheter is placed in the bladder during the operation to keep the bladder collapsed. An incision just to the left of the midline is made from the crest of the superior ramus of the pubis to the level of the umbilicus, and the abdo-

men is opened. A self-retaining retractor is put in the wound, and the patient is placed in a Trendelenburg position. The pelvic structures are inspected and palpated for evidence of extension of the carcinoma, and the liver and the aortic gland region are palpated for the same reason. If there are no demonstrable metastases to render the case inoperable, one proceeds with the operation (Fig. 1157). A large Kelly or Ochsner clamp is placed on each broad ligament near the margin of the uterus for traction, hemostasis, and to prevent the passage of malignant cells through the clamped tubes, blood vessels, and lymphatics during the manipulation incident to the operation. The dissection begins on the right side. The uterus is drawn to the left, drawing taut the right infundibulopelvic ligament with its contained ovarian vessels. The ligament is doubly clamped, cut, and doubly ligated with No. 1 chromic catgut close to the lateral pelvic wall, care being taken not to injure the nearby ureter. The ligament is then drawn medially and the peritoneum of the broad ligament further incised to the round ligament at a point near the lateral pelvic wall. Here the round ligament is ligated and cut. The incision in the anterior peritoneal fold of the broad ligament is continued medially across the vesicouterine fold The bladder is then gently dissected from the cervix for a short distance with the uterus drawn upward. The uterus is again drawn to the left, and the loose connective tissue of the right broad ligament is freed from the lateral pelvic wall and its vessels.

Then traction is placed on the posterior peritoneal layer of the broad ligament, and the ureter which usually rises with this layer is identified A careful dissection of the surrounding connective tissue is done, exposing the ureter from near the site of ligation of the ovarian vessels to a point near the cervix. Care should be taken not to injure the sheath about the ureter for in this sheath run the vessels which supply the ureter Meigs has called attention to the blood supply of the ureter coming through branches from the following arteries in the order given: the renal, the ovarian, the aorta, the hypogastric, the uterine, and the vesicles. He believes that the ureter will be safe if no successive three of these are cut, and he therefore conserves the hypogastric branch inasmuch as it is necessary to cut the uterine and vesical branches. This small hypogastric branch to the ureter arises from the hypogastric artery 1 to 3 cm. below the bifurcation of the common iliac artery. However, Curtis states that the hypogastric branch is not definite or unvarying, "nor is the hazard of ureteral injury largely dependent on its preservation"

The dissection is carried along the *anterior* aspect of the ureter until the latter is found to run in a canal deep to the uterine vessels and a portion of the cardinal ligaments. The operator's finger is gently passed through this canal, keeping on the superior aspect of the ureter and deep to the uterine vessels (Fig. 1157). The finger tip is brought out anteriorly in the region of the vesical fascia. A ligature of No 1 chromic catgut is then passed backward along the track followed by the finger, under the uterine vessels and above the ureter. This and another similar ligature are tied about the bundle of tissue laterally close to the origin of the uterine artery from the hypogastric artery. A clamp is placed medial to the ligatures and the bundle is cut between the clamp and the ligatures The cut bundle is retracted medially with the clamp, exposing the ureter as it passes into the bladder in the deep fascia between the lateral edges of the cervix and the bladder. This fascia

is dissected, separating the ureter from all connections with the cervix, displacing the ureter laterally, and exposing the ureter as it enters the bladder.

All of the above procedures are then repeated on the left side. Following this the uterus is drawn anteriorly, putting the sacrouterine ligaments on the

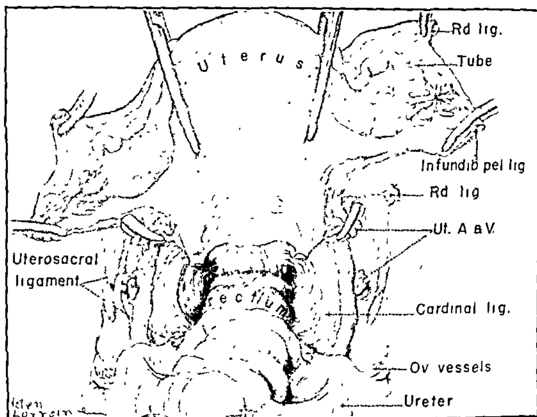



Fig. 1158.—Cervical carcinoma; radical operation. An incision through the posterior parietal peritoneum joins the sites of ligation of the ovarian vessels. It crosses the uterosacral ligaments and the rectouterine fossa. The rectum is separated from the vagina. The uterosacral ligaments have been cut and ligated. The ureters are exposed.

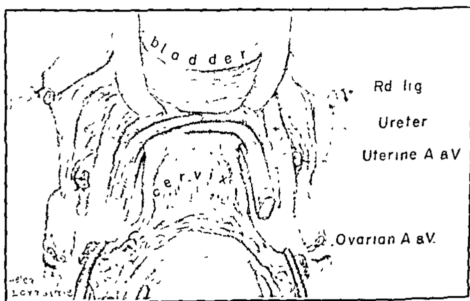



Fig 1159—Cervical carcinoma; radical operation The bladder has been dissected downward so that the superior half of the anterior wall of the vagina is exposed. Large right angle clamps are placed transversely across the vagina in its mid portion The vagina is transected distal to these clamps

stretch. An incision through the posterior parietal peritoneum is then made from the site of ligation of the ovarian vessels on one side to the same point on the other side. This incision passes across the uterosacral ligaments and across the floor of the rectouterine fossa. Care must be taken not to injure the rectum. This organ is separated from the vagina, and the uterosacral ligaments are further exposed. These ligaments are then clamped, cut, and ligated, care being taken not to injure the nearby ureters (Fig. 1158).

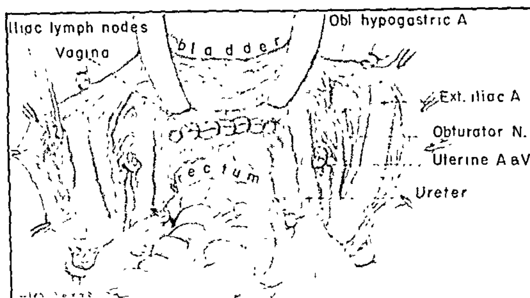



Fig. 1160.—Cervical carcinoma; radical operation. The vaginal stump has been closed. An iliac lymphadenectomy has been performed bilaterally.

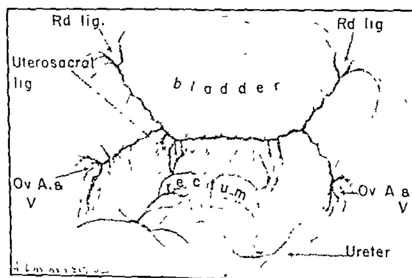



Fig 1161.—Cervical carcinoma; radical operation. Peritonealization is done as in a less radical hysterectomy if possible.

The uterus now is attached *only* by the vagina and by portions of the cardinal ligaments. These ligaments are a basal condensation of the fascia of broad ligaments and include the uterine vessels. They have been exposed and partly dissected by the foregoing procedures and must now be removed as an important step in the operation because of the frequency with which carcinoma has extended

into them. The dissection of these ligaments begins on each side at the la pelvic wall and extends medially toward the uterus, exposing the underlying le ani muscle. The dissected ligaments are drawn medially under the ureters, the uterus is again put on the stretch. Its only attachment now is the v (Fig. 1159). The bladder is further dissected from the vagina so that the sup half of the vagina is exposed. Large right angle clamps are then put transve across the vagina in its mid portion and the vagina is cut across distal to clamps. The cut distal portion of the vagina is closed with sutures of chromic gut while the vagina is being cut, and the uterus, appendages, parametria, and ments are removed in one piece An alternate way is to put two rows of cl across the vagina, cut between them, and later suture the remaining portion o vagina.

If it has not been done during the foregoing procedures, the pelvic ly nodes and associated tissues are then removed essentially as described in the po of the text relating to the Taussig iliac lymphadenectomy. Ideally, one woul move these structures and the uterus and its appendages all in one piece, but so is not generally practical.

There is now a large raw area in the pelvis in which are exposed the le ani muscles, the vaginal stump, the ureters, the vessels of the pelvic wall, the terior surface of the bladder, and the anterior wall of the rectum (Fig. 1160). area should be covered with peritoneum. Usually the short round ligament st cannot be brought to the vaginal stump, but if it is possible to do so they brought and sutured there. Peritonization is brought about, so far as possibl the manner used when a less radical hysterectomy is done (Fig. 1161), but it be necessary to suture the bladder peritoneum to the rectal peritoneum acros vaginal stump, and it may be necessary also to utilize the sigmoid colon to and isolate remaining raw areas.

The abdomen is then closed in layers. A drain is rarely used, but if the indication for drainage the drain should be brought out vaginally, before peri zation, through an interval left in the line of suture of the vagina.

## Intraepithelial Carcinoma of the Cervix

The growing acceptance in recent years of the concept that carcinoma ma first be confined to normal epithelial bounds and only later become invasive brought a new phase to the subject of cervical carcinoma as regards staging, t ment, and prognosis. It has been suggested that this noninvasive or preinv phase be designated as stage 0 (zero). Proper treatment in this stage sh result in practically a 100 per cent cure rate. What then is proper treatment?

There is increasing evidence that these intraepithelial lesions may progre frank invading carcinoma, and at least 18 to 20 cases have been reported in w such progress has been observed. However, pathologists will often differ am themselves as to the diagnosis in a given case. As the diagnosis may be con versial and as the condition is by definition noninvasive at the time and sit diagnosis, the proper treatment might well differ from the treatment of fra invasive carcinoma.

It is seen that the most favored, though not necessarily the best treatmen total hysterectomy with or without removal of the ovaries. Many advise conse tion of ovarian function in the younger patients

It is our opinion that there has not been a sufficiently long follow-up of enough patients to determine the best treatment. However, we advocate in general the method of the above majority, namely, total hysterectomy with salvage of ovarian function in younger patients.

Nevertheless, to apply this treatment to all cases of pure intraepithelial carcinoma might work an unnecessarily severe hardship on the patient, as in the case of a young woman about to marry. It has been shown that the average age of patients with carcinoma in situ (38.7) is about nine years younger than those with invasive carcinoma (48) (Younge; Pund and Auerbach), indicating that carcinoma in situ progresses slowly. Furthermore, Younge reports six patients who became pregnant after having been apparently cured by only cauterization of the cervix, the cauterization having been done before the diagnosis was established except in one case. Of 43 cases treated by cauterization, 85 per cent were apparently cured if the surface only was involved and 37 per cent if the lesion extended into the cervical glands. Younge does not advocate this treatment but he believes that radical therapy may be safely delayed in some of the patients to preserve the reproductive function.

Therefore, under rare circumstances it may be permissible for the patient to have only local treatment to the cervix (e.g., conization) or no treatment at all for a period of time, but in such cases the patient should be kept under the closest observation and be made aware of the possible risk.

As pointed out earlier, the preferred treatment is total hysterectomy with or without bilateral salpingo-oophorectomy The extent of the surgical procedure should lie somewhere between the radical operation for frank carcinoma of the cervix and the total hysterectomy for benign uterine disease. It is generally considered unnecessary to do a lymph node dissection, but the dissection should otherwise be wide, and more of the vagina should be removed than in the case of hysterectomy for benign disease, but less than in the case of invasive carcinoma.

A word of warning should be given Intraepithelial carcinoma is frequently associated with invasive carcinoma elsewhere in the cervix. The latter should be ruled out before the institution of treatment for intraepithelial carcinoma, because the treatment proposed above for this noninvading lesion is entirely inadequate for invading carcinoma of the cervix.

## TREATMENT OF CARCINOMA OF THE ENDOMETRIUM

Primary carcinoma of the body of the uterus arises from the endometrium One finds that the disease is commonly called carcinoma of the corpus uteri or carcinoma of the fundus uteri. There may be slight objection to the former designation as being less specific than carcinoma of the endometrium, but the latter, carcinoma of the fundus, is in general objectionable because it is often inaccurate. The fundus of the uterus is that part most distal from the cervix or, to be more specific, that part of the uterus above a plane passing through the points of entrance of the uterine tubes. Carcinoma of the endometrium may, and frequently does, occur below the fundus. It is usually impossible to determine the exact location and extent of the disease preoperatively. For the reasons stated, we prefer the appellation carcinoma of the endometrium.

There are many reasons why the subject of carcinoma of the endometrium should be discussed separately from that of carcinoma of the cervix, but the main reason why the subjects are separate in this text is that in general the respective treatments of the two conditions are distinctly different.

As in the case of carcinoma of the cervix, hysterectomy was the first effective treatment of carcinoma of the endometrium. The results, though poor, were superior to those for carcinoma of the cervix. When radium became available, it was used first in the inoperable cases and then in the operable cases. However, irradiation therapy has never received the widespread acceptance in endometrial carcinoma that it has in cervical carcinoma, except in the inoperable cases.

It can be said with certainty at the present time that it is the consensus of those experienced in the treatment of carcinoma of the endometrium that complete surgical extirpation of the entire uterus and its adnexa is of utmost importance in the treatment of operable cases. Exceptional is Heyman, who believes that surgery should be used only in cases in which radiotherapy has failed. There is no difference of opinion that inoperable cases be irradiated only.

Not only is it almost unanimous that surgery is the mainstay in the treatment of operable cases, but the majority of writers believe that surgery plus irradiation is the treatment of choice. One finds little difference with this viewpoint; the points of controversy are chiefly how to irradiate, and, to a less extent, when.

The majority of writers believe that irradiation should be preoperative and that it should be accomplished with radium. Among these are Scheffey and associates. Another group advises the use of radium and x-ray in addition to surgery. This group includes Corscaden, Crossen, Kamperman, and Te Linde. X-ray alone is used prior to operation by Miller.

The radium is placed within the uterine cavity. In the majority of cases, though to a less extent than formerly, the units of radium are placed in tandem in a single tube. Because the uterine cavity varies in size and may be distorted in disease, the use of a single tube may not deliver a uniform or adequate dose to the lesion. To overcome this partly, methods have been developed in which the uterine cavity is filled with multiple units of radium. The latter methods, though having much to commend them, are more troublesome and perhaps carry a greater operative risk. Furthermore, at best they are imperfect.

It would seem desirable at this point to state the purpose of preoperative irradiation. It is to cause devitalization of tumor cells and to minimize or prevent the spread of cancer at the time of operation. However desirable it would be to destroy all cancer cells by irradiation, this is not the expected effect of the irradiation, for studies on extirpated uteri which were irradiated preoperatively show that residual carcinoma cells are present in approximately 50 per cent of the cases. This figure can be reduced by more attention to details in placing the radium, but it will remain sizable. The effect of the radium will be slight or absent not far distant from the radium, and it is for this reason that x-ray is used to enhance and extend the irradiation effect Miller uses x-ray alone preoperatively for an evenly distributed devitalizing effect on malignant cells throughout the pelvis. Some writers advocate postoperative x-ray therapy.

For inoperable cases all agree that x-ray and radium in maximum doses are indicated, and it is in these cases that the "multiple source" or "packing" methods of applying radium may be most useful.

The dosage of radium recommended varies but seems to average about 4,000 milligram hours. There is a tendency to give larger doses in the inoperable cases.

The recommended interval between the completion of irradiation and the time of surgery varies from a few days to many months. Most writers recommend an interval of six to eight weeks to allow the irradiation reaction to subside but not to delay too long the most important part of treatment.

Most surgeons are content with surgery less radical than that for carcinoma of the cervix. In most cases the entire uterus and both adnexa are removed, but little of the vagina is excised, and the parametria are not widely removed nor are the pelvic lymph nodes dissected One reason that an iliac lymphadenectomy is not generally employed is that the lymph drainage from the upper portion of the uterus, the part most commonly affected, is through lymph vessels which accompany the ovarian blood vessels and drain into the inaccessible nodes about the great vessels in the lumbar region. Thus, dissection of the iliac nodes would be futile in most instances. When carcinoma involves only the lower end of the endometrial cavity, there would be more reason to do an iliac lymphadenectomy. However, the location and extent of the lesion is rarely known, and involvement of the lower end only is rare. Endometrial carcinoma in this location and extending into and beyond the cervix might best be treated as carcinoma of the cervix.

In operating for endometrial carcinoma, most operators point out the importance of closing the cervix with sutures before the laparotomy is performed, and the importance of clamping or ligating the tubes and broad ligaments as soon as the abdomen is opened to prevent extension or spillage incident to the operative manipulation. No clamps should be put on the uterus itself.

It is of utmost importance that each case be considered individually with respect to treatment. With this in mind we have developed the following plan of treatment:

When a patient, during or after the menopause, is suspected of having endometrial carcinoma, radium is placed in the uterus at the time of diagnostic curettage. If carcinoma proves to be present, the full dose of radium is given; if carcinoma is not found, the radium is removed after a dose of 1,800 to 2,400 milligram hours. In a younger patient no radium is used unless and until the diagnosis of carcinoma is established Surgery is advised in all operable cases, and preliminary irradiation with radium in almost all cases. In a few cases of early carcinoma of low degree of malignancy, surgery alone is relied upon, especially if radium had not been made available at the time of diagnostic curettage.

Radium is used as follows: Four 25 mg capsules of radium, with a 1 mm. wall of platinum, are placed in tandem in a rubber sac. The sac is tied between each radium capsule, thus producing in effect a very flexible jointed tube. This is inserted into the uterine cavity and tends to conform to any irregularities which may be present. The technic of preparation and insertion of this radium is as in the similar part of the treatment of carcinoma of the cervix (Figs. 1151 and 1152). The radium is left in place 100 hours so that a dose of 4,000 milligram hours is given. A definite policy regarding additional irradiation by x-ray has not been reached at this time, but it is thought best to follow the radium immediately with a full course of x-ray therapy, given as for carcinoma of the cervix. Six to eight weeks after preoperative irradiation is completed, be it radium or radium and x-ray, operation is performed. Occasionally postoperative x-ray therapy is given.

The cervix is closed vaginally with figure-of-eight sutures of catgut or other material and a laparotomy is performed. The abdomen is explored for evidence of metastases. The broad ligaments, including the tubes, are clamped for traction and to prevent extension of carcinoma. No clamp is placed on the uterus and manipulation of this organ is kept to a minimum. Both tubes, both ovaries, and the entire uterus are removed. The technic of this operation is generally essentially the same as in hysterectomy and bilateral salpingo-oophorectomy for benign disease except that there is a wider excision of tissue. The ovarian vessels are ligated at the pelvic wall, the broad ligaments are widely excised, the round ligaments are cut no closer to the uterus than halfway between it and the internal inguinal ring, the dissection hugs the cervix less closely, and a greater amount of vagina is removed. The dissection is not as wide as in the surgical treatment of carcinoma of the cervix, and iliac lymphadenectomy is not done routinely. In other words, the extent of the operation lies between the operation for benign disease and that for carcinoma of the cervix.

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# CHAPTER 80

# THE UTERUS (CONTINUED)

## INTRINSIC AND EXTRINSIC OPERATIONS FOR BENIGN LESIONS

RANDOLPH H. HOGE

## HYSTERECTOMY

**Indications.**—Aside from the treatment of malignant disease, which is discussed elsewhere, abdominal hysterectomy may be indicated in such conditions as fibromyoma, adenomyoma, certain infections, in some functional disturbances, and when, for other reasons, the ovaries are being removed. Vaginal hysterectomy may be employed in some of these cases, and is liberally employed by some. However, in these diseases we prefer the abdominal route except under rare circumstances, or in selected instances where vaginal plastic repair is also required. The latter cases are discussed elsewhere.

**Definitions.**—Hysterectomy may be either total or subtotal, depending on whether the cervix is removed or not. Panhysterectomy, complete hysterectomy, and total hysterectomy are synonyms and have no reference to the disposal of the adnexa. Supravaginal, supracervical, and subtotal hysterectomy are essentially synonymous, though there may be degrees of subtotality. Removal of little more than the fundus is a form of subtotal hysterectomy which is referred to by some as fundectomy or fundic hysterectomy. *Fundus* is not to be confused with *corpus*, of which it is only a part. Such confusion appears quite common in the literature. Radical hysterectomy is a term used in connection with the treatment of malignant uterine disease. Its minimal connotation includes the removal of the entire uterus and all the adnexa. It is discussed in the appropriate chapters.

**The Adnexa.**—It may or may not be necessary or desirable to remove the adnexa when a hysterectomy is performed for benign disease. In most instances the adnexa should be left in place unless sufficiently diseased themselves to indicate their removal. This is particularly true in women prior to the menopause. The ovaries, of course, are left in if healthy on account of their important endocrine function, and the tubes, if healthy, are left lest their removal injure the ovarian blood supply. At the time of the menopause and thereafter, the ovaries are probably of little or no functional importance and may be removed along with the uterus as a prophylaxis against ovarian carcinoma.

### Management of Myoma Uteri

Myomas of the uterus probably are the most frequent indication for hysterectomy; but not all myomas require hysterectomy. The majority of myomas are

small and asymptomatic and require no treatment. In such cases the patient is kept under observation. If, because of symptoms or the size of the tumor, treatment is indicated, hysterectomy is the most commonly used method. However, irradiation and myomectomy are two other methods sometimes used.

Irradiation.—Irradiation may be used if the patient is a poor operative risk or refuses surgery; otherwise surgery is preferable. Irradiation should be used only if the patient is near the menopause, the tumor is not pedunculated and is no larger than a grapefruit, there is no infection, and there is no other condition requiring laparotomy. Irradiation should always be preceded with a diagnostic curettage to rule out carcinoma, and may be either with x-ray or, preferably, with intrauterine radium. The latter is given with units of radium in tandem inserted into the uterine cavity similar to a part of the treatment of cervical carcinoma (Figs. 1151 and 1152); 2,400 milligram hours, more or less, are a satisfactory dose. The effect on the tumor is indirect, through the inhibition of ovarian function, so the tumor regresses but never disappears. That the menopause is induced and a diseased organ remains are two of the objections to the irradiative method of treatment.

Myomectomy.—If surgery is used, it may consist of myomectomy or hysterectomy. Theoretically, myomectomy, during the child-bearing period, is ideal treatment in that it gets rid of the disease and leaves a functioning organ. It is indicated in pedunculated tumors in young women and in other cases in which children are desired and the operation feasible. There are many factors which make hysterectomy preferable in many cases. In deciding between myomectomy and hysterectomy the following factors should be considered: childbearing; operative difficulties; incidence of postoperative adhesions and obstruction; associated disease of the uterus and/or adnexa; persistence of symptoms; residual or recurrent myomas; later occurrence of other uterine disease; and the danger of labor. Suffice it to say that the operation of myomectomy may be much more difficult than hysterectomy, but even then it sometimes may be justified in women desiring and capable of having children. However, we would hardly go so far as one advocate of myomectomy, Victor Bonney, when he removed as many as 225 of these fibroids from a single uterus. He feels that for women forty-one years old and younger "myomectomy should, broadly speaking, be the operation of choice."

An important objection to and risk of myomectomy is hemorrhage. This should be prevented so far as possible by temporarily clamping the blood vessels supplying the uterus Bonney uses ring sponge forceps to compress the ovarian vessels and has developed a special clamp to use on the uterine vessels. The wounds should, of course, be adequately sutured with catgut in as many layers as seems indicated. Another objection to myomectomy is the scarring left on the surface of the uterus. So far as possible all of the tumors should be removed through one uterine incision, and the uterine incision or incisions, when possible, should be peritonealized. In subsequent pregnancy the obstetrician should be advised that myomectomy has been performed.

Of course, a submucous myoma presenting through the external os is best removed vaginally, and hysterectomy or additional myomectomy may or may not be indicated for any remaining myomas. Often the additional operation is not necessary.

Total vs. Subtotal Hysterectomy.—In doing a hysterectomy for myoma of the corpus uteri, or for other benign conditions of this organ, one must decide whether

to remove the cervix. The advantage of removing the cervix is that the cervix is frequently diseased at the time or may become diseased later. Furthermore, it seems to have little or no value to the patient once the corpus is removed. Crawford and his co-writers have emphasized the importance of recognizing diseases of the cervical stump as the origin of many patients' complaints. Our most compelling indication for total, as opposed to subtotal, hysterectomy is the prevention of carcinoma of the cervix. In a former study over 4 per cent of our cases of carcinoma of the cervix were cases of carcinoma of the cervical stump, and it is our present impression that a study of our subsequent cases would show an even higher percentage. We are impressed with the needlessness of these patients' developing carcinoma of the cervix.

Objection to the total abdominal hysterectomy has been voiced partly on the ground that the vagina is shortened and its support lessened. It is our impression that neither of these conditions need result, and actual measurements by Castallo and Wainer showed an increase in vaginal length following total and subtotal hysterectomy with the greater increase following the total operation. Another objection, that the removal of the cervix leaves the vagina without adequate secretion, has not been borne out in our experience if we can judge by the lack of complaint of this by our patients.

The objection to the total operation that should be given most consideration relates to the relative mortality of the two operations. Statistics on this vary. Some show a higher mortality for the subtotal operation, but this is probably more apparent than real, because the subtotal operation is apt to be performed on the poor-risk patients. A total hysterectomy on all patients regardless of local or general complicating factors would result in an increased mortality over the subtotal operation even in the most expert hands. The less expert the surgeon is, the greater will be the increased mortality.

In studying 1,778 cases of subtotal hysterectomy and our cases of cervical stump carcinoma, we have found indirect and suggestive evidence that approximately 0.73 per cent of cervices left behind at operation will be the site sooner or later of carcinoma. This figure is of the same order as those in similar studies reported by others. Assuming that this figure is approximately correct, then the increased mortality due to removing the cervix must be considerably less than 0.73 per cent in order to justify the removal of the cervix in hysterectomy solely on the basis of cancer prophylaxis This is because patients may have years of life postoperatively before developing cancer, and because many of those who develop cancer will be cured.

In complicated cases or in inexpert hands, when the total operation is done, there will be also the risk of increased morbidity, due, among other things, to hemorrhage, injuries to the urinary tract or rectum, and prolongation of the operation. Thus, the relative morbidity of the two procedures also must be taken into consideration in choosing between them.

Ten to fifteen years ago subtotal hysterectomy was the routine operation and total hysterectomy was done only in exceptional cases. Now the ratio is reversed, but it is still felt most strongly that the total operation should not be done in all cases. The literature reveals a similar trend throughout the country.

Local conditions, such as pelvic inflammatory disease, endometriosis, and poor exposure, and general conditions, either present preoperatively or developing during operation, which may at times make the shorter and sometimes less difficult operation more desirable, should influence the surgeon toward the subtotal rather than the total operation, especially if the cervix is healthy. If the cervix is not healthy and the subtotal operation is selected, the cervix should be appropriately treated before the laparotomy or after the laparotomy wounds have healed safely. It is unwise, because of the possibility of causing internal hemorrhage through traction or manipulation, to operate on the cervix immediately after laparotomy.

### Other Benign Uterine Disturbances

The treatment of adenomyomas is usually similar to that of leiomyomas. Rarely, uterine infections, such as tuberculosis of the endometrium, require hysterectomy. Menorrhagia during or close to the menopause may require active intervention. Radium, applied as described for myomas, in dosage of from 1,200 to 1,800 milligram hours is effective However, radium is less used for this purpose than it was a few years ago. We now restrict its use to women over forty years of age, who require major therapy, but who are poor operative risks or refuse hysterectomy. Many women nowadays are given estrogens and these may induce worrisome bleeding even after irradiation. Furthermore, there is evidence that women who have menorrhagia at the time of the menopause are more apt to develop carcinoma of the endometrium than are other women. For these reasons our preferred treatment, if symptoms justify it, is hysterectomy, for there is then no risk of future trouble with the uterus.

### The Technic of Total Hysterectomy

Immediately before the laparotomy the vagina is treated with a suitable antiseptic and the bladder is catheterized. The catheter is left in place and kept open during the entire operation. The abdomen is prepared and a lower left paramedian or midline incision is made. We prefer the former. The patient is then placed in the Trendelenburg position, and the abdomen is explored.

An Ochsner clamp is placed close to the uterus on each broad ligament for traction and hemostasis A No. 1 chromic catgut ligature is placed on each round ligament a short distance from the uterus. One end of the ligature is left long and clamped with a hemostat. A Kelly clamp is then placed on each round ligament medial to the ligature and the ligament is cut between the clamp and the ligature. This opens the broad ligament. Curved scissors are then inserted beneath the anterior peritoneal layer of the left broad ligament and with successive blunt and sharp dissection the peritoneum is undermined and cut to the level of the cervix, then across the vesicouterine fold, and up the right broad ligament to the sectioned right round ligament (Figs. 1162 and 1163).

Then on each side the index finger is inserted under the tube, ovarian ligament, and associated vessels through an avascular area in the broad ligament (Fig 1163). Two Ochsner clamps extending from the top of the broad ligament into the opening thus formed are placed across the portion of the broad ligament containing the tube, ovarian ligament, and vessels on each side The structures between the clamps

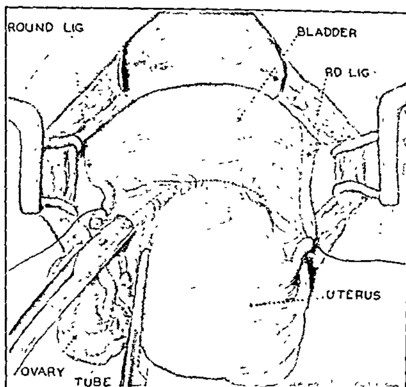



Fig. 1162.—Total hysterectomy. Usually a clamp is placed on each broad ligament close to the uterus. Each round ligament is ligated and the ligature is clamped. The left round ligament is cut between the ligature and a Kelly clamp Scissors are inserted under the anterior leaf of the broad ligament.

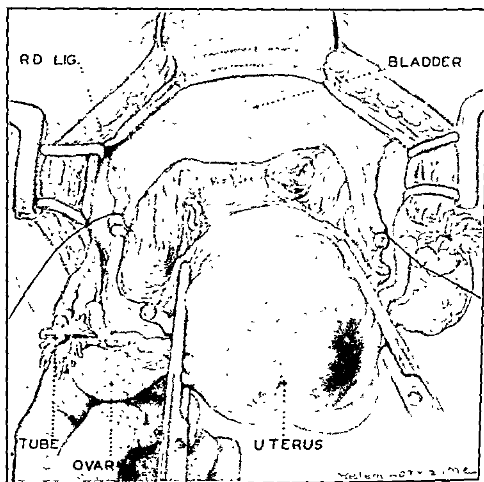



Fig 1163—Total hysterectomy The peritoneum is incised along the line indicated in : preceding figure. On the left a finger is inserted to make an opening throug'ı an avascular ıce ın the broad ligament under the tube, ovarian ligament, and vessels These structures will doubly clamped and cut.

are then cut. The pedicle held by each lateral clamp is then securely tied with two or more suture ligatures of No. 1 chromic catgut as the lateral clamp is removed (Fig. 1164).

The adnexal pedicles having been cared for thus, the dissection of the broad ligament is continued to the level of the uterine vessels as they approach the cervix (Fig. 1164). This is largely blunt dissection. The bladder is then dissected from the cervix and upper portion of the vagina (Fig. 1165). This, too, is chiefly blunt dissection and can be carried out satisfactorily for the most part with a gauze sponge. Some sharp dissection is usually necessary in and near the midline. Care should be taken not to open the numerous blood vessels in this area. As the bladder is pushed downward lateral to the vagina, the ureters are somewhat displaced laterally and downward, carrying them to a safer position.

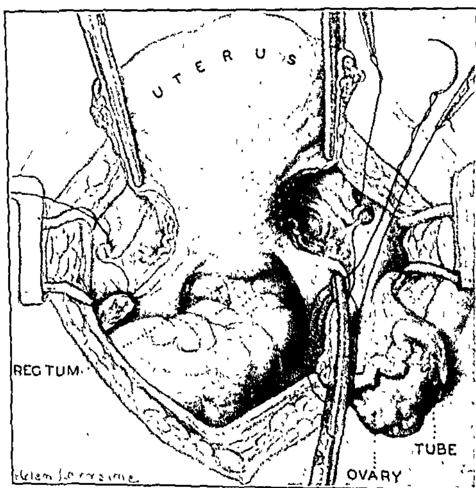



Fig. 1164.—Total hysterectomy. The uterine vessels have been exposed on each side. The pedicle containing the tube, the ovarian ligament, and associated vessels has been ligated on one side and is being ligated on the other.

Now three Ochsner clamps are placed on the exposed uterine vessels on each side, care being taken to avoid the ureter. The two distal clamps are placed at the cervical level at a right angle to the long axis of the uterus. The tip of the most distal clamp touches the cervix. The intermediate clamp takes a much smaller bite of tissue. One of the purposes of this clamp is to prevent this tissue from slipping through the jaws of the most distal clamp. The most proximal clamp is placed close to the uterus and more or less parallel with it. The uterine vessels are now cut between the proximal and the intermediate clamps (Figs. 1165 and 1166).

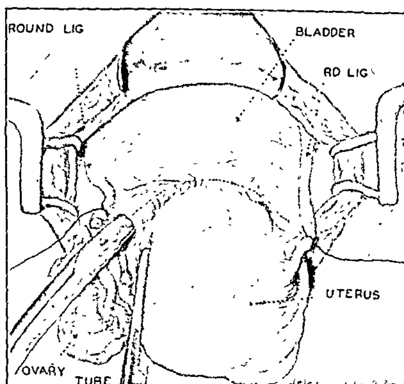
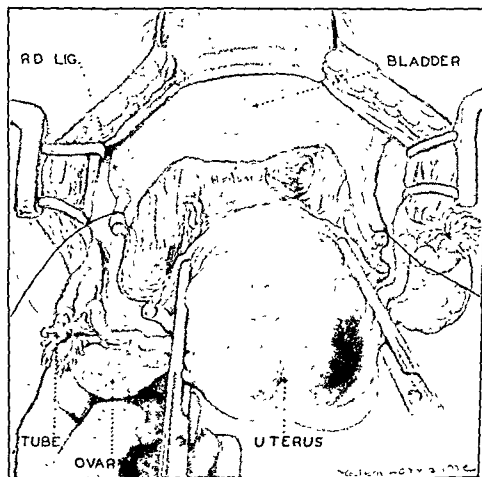



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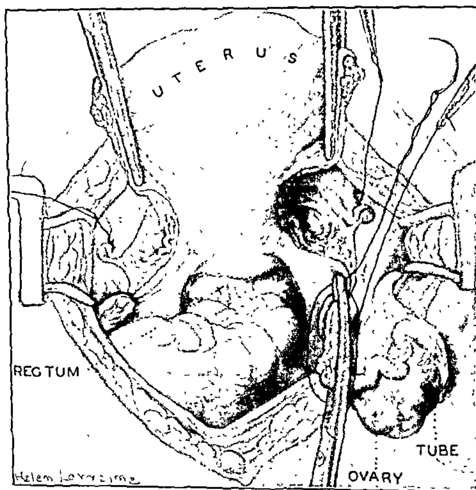



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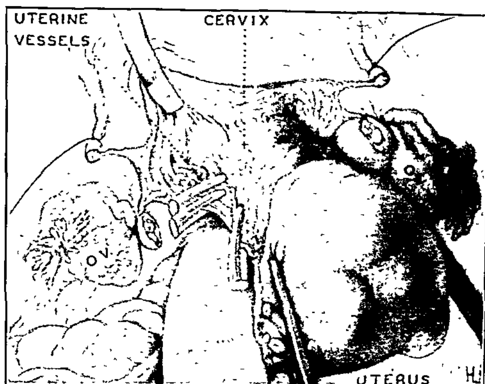



Fig. 1165.—Total hysterectomy. The bladder is dissected from the cervix and upper part of the vagina. Three clamps at right angles to the uterus are on the exposed uterine vessels. The vessels will be cut along the broken line.

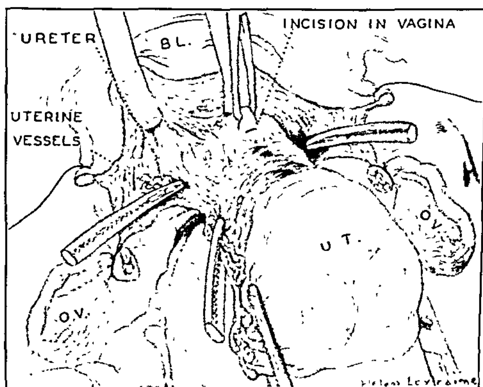



Fig. 1166.—Total hysterectomy. The uterine vessels are cut. The intermediate clamp on each side is not shown; in practice it is left in place until the pedicle is ligated. The ureter is seen under the left uterine vessels. The vagina is opened anteriorly.

The next step is to open the vagina. An Oschner clamp grasps the anterior wall of the vagina just distal to the cervix and clear of the bladder (Fig. 1166). The vagina is then incised transversely just proximal to the clamp, and circumcision of the vagina is carried out. This is facilitated by placing a tenaculum on the anterior lip of the cervix and drawing the cervix through the vaginal wound. Usually it is helpful to shift the tenaculum from the anterior lip to the posterior lip as the incision progresses. Bleeding vessels will be encountered along the cut margin of the vagina and are clamped (*Fig. 1167*).

In some cases it is preferable to open the vagina initially laterally or posteriorly. If opened laterally the paravaginal tissues first must be camped close to the vagina and dissected from it.

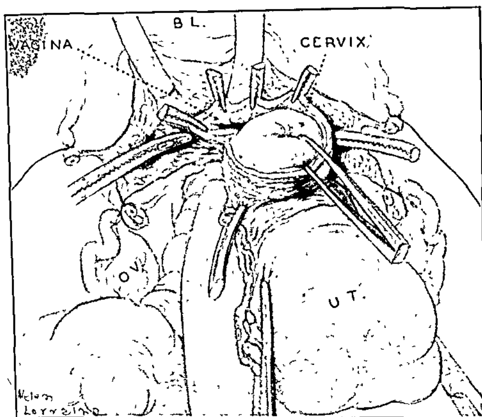



Fig. 1167.—Total hysterectomy Circumcision of the vagina is facilitated by a tenaculum on the cervix, drawing the latter through the vaginal wound.

Completion of the circumcision of the vagina entirely frees the uterus, which is removed. Then each pedicle of the uterine vessels is suture ligated, and ligated a second time, the clamps on these vessels being removed.

Then there is taken on each side of the vagina a figure-of-eight suture of No. 1 chromic catgut (Fig. 1168). This suture should include portions of the paravaginal tissue between the main uterine vessels and the vagina and should also include the full thickness of the vagina at each lateral angle. This stitch sometimes includes the uterosacral ligament. Occasionally two figure-of-eight sutures on each side are desirable.

The next step is to complete the closure of the vagina. This is done with a running lockstitch of No 1 chromic catgut It includes the full thickness of the vaginal walls with the peritoneum posteriorly (Fig. 1169). Only if there has been gross

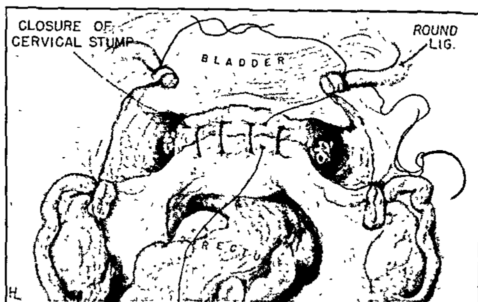



Fig. 1174.—Supravaginal hysterectomy. The cervix has been closed with sutures A suture has been passed through the cervix and through the broad ligament margin of the right round ligament. A similar suture will be placed on the left These sutures will anchor the round ligaments to the cervix.

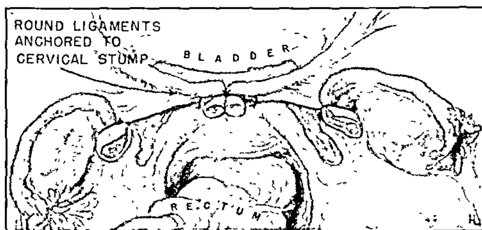



Fig. 1175—The round ligaments have been anchored to the cervix and their cut ends have been tied together, using the ligatures placed on them earlier

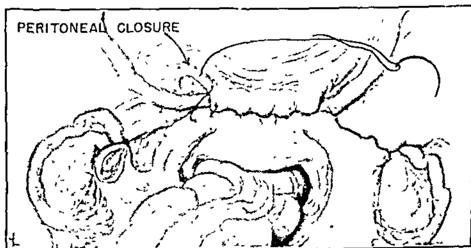



Fig 1176—The right broad ligament has been closed, burying the adnexal pedicle The bladder flap of peritoneum has been sutured to the posterior aspect of the cervix The left broad ligament will be closed All of this is done with a running suture

### Hysterectomy With Salpingo-oophorectomy or Salpingectomy

Removal of the adnexa with the uterus modifies to some extent the technic of the hysterectomy. If the tube and ovary on either side are to be removed, the top of the broad ligament is not cut adjacent to the uterus as described above, but the adnexa are clamped and elevated, exposing the infundibulopelvic ligament containing the ovarian vessels. The tube and ovary are then removed as described for salpingo-oophorectomy (Figs. 1187-1189) except that these organs are left attached to the uterus The rest of the operation for hysterectomy is the same as described above except that, in peritonealizing, the ovarian vascular pedicle must be buried instead of the adnexal pedicle. Actually, removal of the tube and ovary usually makes the performance of hysterectomy simpler.

If the tube and not the ovary is to be removed with the uterus, the first steps of the operation are the same as for salpingectomy except that the tube is left attached to the uterus. From then on the technic of hysterectomy is as described.

### The Technic of Supravaginal Hysterectomy

If a supravaginal hysterectomy is performed, the first steps are similar to those described for total hysterectomy (Figs. 1162-1171). However, the dissection is not carried quite so low. The bladder is not dissected from the vagina, and the vagina is not opened. Furthermore, the uterus is removed by cutting across the cervix (Fig. 1172) and this is done in such a fashion that the cervical stump is coned out (Fig. 1173). The suture ligatures which tie the uterine vessels include a bite of cervical tissue. Ligation should be double on each side. The cervix is closed with interrupted or figure-of-eight sutures of No. 1 chromic catgut (Fig. 1174). The round ligaments are anchored to the closed cervical stump with sutures which pass through their broad ligament borders (Fig. 1174) and their cut ends are tied together (Fig 1175), using for this purpose the ligatures which had been placed on their cut ends earlier Peritonealization is carried out (Fig. 1176) in a fashion similar to that described for the total hysterectomy.

## SUSPENSION OF UTERUS

### History of Operations for Uterine Retrodisplacement

Apparently the first recorded conception of an operation for correction of uterine displacement was made in 1840, the plan being to shorten *the round ligaments in the inguinal canals.* It was not carried out successfully on a living woman until done by Alexander forty-one years later. In the meantime other operators had attempted to correct retrodisplacements by suturing the uterus or its appendages to the abdominal wall Subsequently (1885) Olshausen reported the operation, now bearing his name, in which the round ligaments at the cornua were sutured to the anterior abdominal wall. In 1899 Ferguson recorded an operation in which the round ligaments were cut and their uterine ends sutured in bilateral incisions in the recti abdominis muscles He later modified this operation. In 1900 Gilliam, apparently influenced by Ferguson's original operation, devised one of his own, in which the intact proximal portions of the round ligaments were drawn through the rectus muscles and sutured to the anterior sheaths He later referred to his operation as "the pioneer ventrosuspension of the uterus by means of the round ligaments

in which the ligaments are left intact in their natural investments." There have been numerous modifications of this operation.

In 1901 and 1903, respectively, Webster and Baldy independently reported the operation which now bears their names jointly. In this operation each round ligament is brought through an opening made in the broad ligament just under the ovarian ligament and is sutured on the posterior aspect of the uterus.

Other operations devised and used during the foregoing period included shortening of the round ligaments through the vagina, shortening of the cardinal ligaments, and shortening of the uterosacral ligaments. There have been many operations devised since In 1915 Kelly wrote, "I present here a record of 50 different operations all designed to correct retrodisplacements—an extraordinary exhibit of the fertility of the surgical imagination. I expect to bring this collection nearly to 100." Now only several of the operations have survived the test of time.

## Indications for the Correction of Uterine Retrodisplacement

Operation for retrodisplacement of the uterus and operation for simple ovarian retention cysts share the distinction of being the two gynecologic operations most often unnecessarily performed. Baldy said in 1915 that in his opinion "nine-tenths of the operations performed on women for retrodisplacements are uncalled for," and added, "I am sorry to say it, but it looks to me as though the possible number of retrodisplacement operations performed in this country is limited only by the number of females in existence." He felt that retroversion was commonly associated with other abnormal pelvic conditions, and that in these cases the symptoms came from the complications themselves and not from the displacements. In the same year Bovée wrote, "I am convinced that uncomplicated uterine retroversion has no symptoms."

Retroversions of the uterus are frequent, occurring perhaps in one out of every six women. In the great majority of cases there are no symptoms. In these cases no therapy is required. In other cases there are symptoms but the symptoms are not necessarily due to the displacements. In many instances the symptoms are caused by associated pelvic conditions or may arise from conditions outside of the pelvis Backache, for example, so commonly attributed by patient and doctor alike to disease of the female generative organs, is more commonly not gynecologic in origin Many other symptoms have been attributed to retrodisplacement, but whether this condition can produce most of the symptoms attributed to it is a moot question. In general, the trend has been toward conservatism. Miller and Kretzschmar reported a steady decrease in the percentage of cases of retrodisplacements operated upon at the University of Michigan Hospital, from a high of 75 per cent in 1901 to 0 9 per cent in 1931.

Many authors now write that they rarely, if ever, operate for the correction of simple uncomplicated retroversion. Before operating for this purpose one must decide if the symptoms are due to the displacement and if the symptoms are sufficient to justify the risk, expense, and inconvenience of the operation.

Our operations for suspension of the uterus are few and, in most instances, are done as a part of an operation to correct other abnormalities in the pelvis. For example, we occasionally suspend a retroverted uterus when doing a resection of

the superior hypogastric plexus for primary dysmenorrhea. We rarely operate with the primary purpose of suspending the uterus, and when we do it is usually for retroversion of the secondary type.

## The Technic of a Modified Gilliam Operation

There is no one operation for retrodisplacement which is best for all cases. The Gilliam operation seems to be among the most popular. It is the one which, with modifications, we use in the great majority of our cases and have found to be most satisfactory.

The unmodified Gilliam operation leaves a passage lateral to each anteriorly sutured round ligament. Gilliam did not believe these openings dangerous, but many surgeons have felt that they may lead to intestinal obstruction. Most of the modifications of the original Gilliam operation have dealt with the obliteration or avoidance of these passages. Modifications of less importance have been concerned with the manner and place of suturing the round ligaments once they have been brought into the rectus muscles.

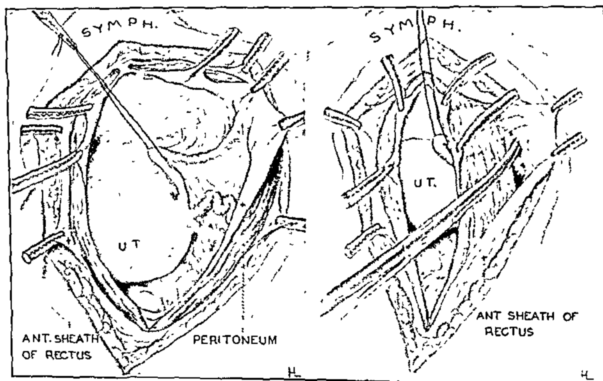
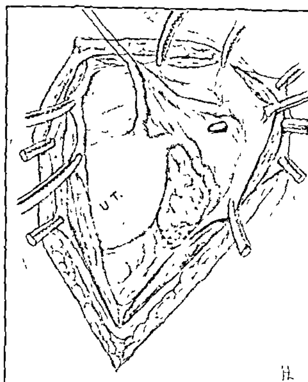



Fig. 1177. Fig. 1178.

Fig. 1177.—Gilliam suspension operation modified. An untied suture has been placed under the left round ligament 4 cm. *from the uterus*. At the lower part of the wound Kelly clamps have been placed on the peritoneum and Ochsner clamps have been placed on the anterior sheath of the rectus muscle.

Fig 1178.—The anterior sheath of the *rectus muscle* has been dissected from the muscle in the lower part of the wound. At a level about 4 cm. above the symphysis pubis a long curved Kelly clamp is inserted extraperitoneally, *lateral to the rectus muscle*.

The following is a description of the operation: A lower *midline* incision is made and the patient is put in the Trendelenburg position. The abdomen is explored and, if indicated, other intrapelvic operations are *performed*. A ligature is then passed under the right round ligament about 4 cm. from the uterus, left *untied*,



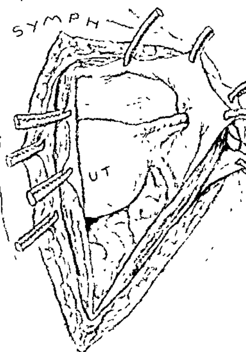




Fig. 1179. Fig. 1180

Fig. 1179.—Gilliam suspension operation, modified Traction is exerted on the w margins, and the Kelly clamp is passed extraperitoneally into the broad ligament near th ternal inguinal ring. The ends of the suture under the round ligament will be grasped by clamp.

Fig 1180.—The long Kelly clamp has been withdrawn, drawing with it the suture a loop of round ligament.

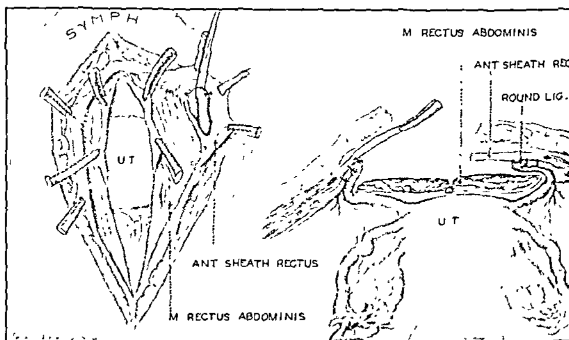



*Fig. 1181.* *Fig 1182*

Fig 1181.—Gilliam suspension operation, modified The loop of round ligament spread out and fastened with interrupted sutures of silk to the undersurface of the anterior r tus sheath The traction suture will be withdrawn

Fig 1182 —A horizontal section, showing the operation completed except for closure the anterior rectus sheath, subcutaneous fascia, and skin Note that there is no passage late to the displaced round ligaments.

and clamped (Fig. 1177). Two Kelly clamps are placed on the edge of the peritoneum and two Oschner clamps on the edge of the anterior rectus sheath in the lower part of the wound. They are placed so that the mid-point between the upper and lower clamps will be about 4 cm. above the symphysis pubis. The rectus sheath is then dissected from the underlying muscle between these clamps and as far lateral as the lateral border of the muscle. Then a long curved Kelly clamp is inserted lateral to the rectus muscle at this level; and, while medial and anterior traction is being exerted on the four clamps attached to the wound margin, the long clamp is passed extraperitoneally, laterally, posteriorly, and then medially toward the broad ligament (Fig. 1178). When the tip of the clamp has passed into the broad ligament in the region of the internal inguinal ring, the peritoneum of the posterior leaf of the broad ligament is nicked over the tip, which is then passed into the peritoneal cavity through the nick (Fig.1179). The ends of the ligature around the round ligament are then grasped by the clamp. One reason for using the ligature rather than catch the round ligament directly in the clamp is to avoid injury to the intrinsic blood supply of the ligament. The clamp is then withdrawn, bringing with it the ligature and a loop of round ligament (Fig. 1180). While traction is continued on the former, the latter is spread out on the undersurface of the anterior rectus sheath and anchored there with interrupted sutures of silk (Fig. 1181). This procedure is repeated on the left side. The uterus should now be found suspended well anteriorly. A finger should be inserted on each side to be sure there is no opening laterally; if the operation has been done properly, there is none (Fig. 1182). If an opening is found, it is closed with chromic catgut sutures. Then the abdominal wall is closed in a routine fashion. Usually the round ligament loops are not joined in the midline.

*Auxiliary Procedures.*—Additional steps are occasionally added to the modified Gilliam operation. If the uterosacral ligaments are relaxed, or if the cervix stays abnormally far anterior, these ligaments are shortened by reefing each one or by suturing them together in the midline. Sometimes the bladder is advanced on the corpus of the uterus, especially if there is a cystocele.

## Suspension After Salpingectomy

In cases in which suspension is indicated and the tubes have been or are to be removed or resected, the following procedure is preferred to the modified Gilliam operation: the intact round ligaments are drawn over the broad ligaments and the fundus of the uterus and are sutured onto the posterior aspect of the fundus and corpus. This operation is similar to the Baldy-Webster suspension except that the round ligaments are drawn over the broad ligaments instead of through openings in the latter. The operation is useful not only in drawing the uterus forward but also as a means of covering the raw area following salpingectomy.

## *Baldy-Webster Operation*

The Baldy-Webster suspension is popular. That it suspends the ovaries better than any other procedure is said to be an advantage. A disadvantage is that it relies on the weaker distal portions of the round ligaments for the forward pull, rather than on the stronger proximal portions, such as are used in the Gilliam operation. Furthermore, herniation of bowel through the opening in the broad ligaments has been reported.

The technic of the Baldy-Webster operation is as follows: A lower midline or a Pfannenstiel incision is made and the patient is put in the Trendelenburg position. A small opening is made through an avascular area in the right broad ligament just inferior to the ovarian ligament. A clamp is passed through this opening and grasps the round ligament about 4 cm. lateral to the uterus. The clamp is withdrawn, drawing with it a loop of round ligament. This is spread out and sutured on the posterior aspect of the uterus with catgut or fine silk, preferably the latter. It is important then or later to suture the round ligament to the broad ligament around the opening which was made in the latter, as prevention against herniation. The same procedures are repeated on the left side. The round ligaments may or may not be united posteriorly on the uterus, depending on the degree of laxity. It may or may not be desirable to shorten the uterosacral ligaments and advance the bladder, as mentioned previously with regard to the Gilliam operation

### Olshausen Operation

The Olshausen operation is favored by some and is the simplest and last of the procedures to be described herein for the correction of retroversion. We do use it, and question its merit. In this operation the uterus is suspended by a sin silk suture on each side between the rectus muscle and the round ligament. T suture passes through the anterior rectus sheath, the rectus muscle, and the perit neum about 5 cm. above the symphysis pubis. It then passes under the round liga ment 1 to 2 cm. from the uterus and goes back through the peritoneum and rectus muscle to be tied later anterior to the rectus sheath. Before tying this suture the round ligament and the parietal peritoneum are scarified in the areas where they will be in contact when the suture is tied. The same procedures are carried out on the opposite side. Then the two sutures are tied and the abdomen is closed

## RESECTION OF THE SUPERIOR HYPOGASTRIC PLEXUS

### Indications

This operation, commonly known as presacral neurectomy, has been performed for over half a century Its chief indication is the relief of dysmenorrhea.

When dysmenorrhea is a symptom of disease in the pelvis, treatment is directed toward that disease. However, the most common type of dysmenorrhea, primary dysmenorrhea, occurs in the absence of any known lesion. Mild cases can be controlled adequately by simple drugs, but severe cases may require surgical procedures The surgical procedures commonly used in the treatment of primary dysmenorrhea are dilatation of the cervix and resection of the superior hypogastric plexus. The first is of value in only a small minority of cases; the second relieves the pain in 80 to 90 per cent of the cases. Resection of the superior hypogastric plexus, however, has the disadvantage of being a major operative procedure and is consequently recommended only in severe cases, usually after simpler methods have failed The operation is of great value in properly selected cases of primary dysmenorrhea. Other indicated procedures may be done at the same time. The operation is of value in some cases of secondary dysmenorrhea, as in the case of uterine adenomyosis when hysterectomy is contraindicated. Greenhill has recommended it in cancer of the uterus and in pelvic pain of unknown etiology.

Ingersoll and Meigs believe that some of their failures were due to having operated upon women whose dysmenorrhea was on a psychoneurotic basis. Primary dysmenorrhea does not occur during anovulatory menstruation. Therefore, these writers advise a test which consists of the inhibition of ovulation through the use of estrogens, then the induction of withdrawal bleeding. If then the patient complains of pain, she is not regarded as a desirable candidate for operation.

Some failures may be due to faulty operations; and it is thought by some that nerve regeneration may account for recurrence of pain in some cases.

We have observed no untoward effects from the operation.

Though the term "presacral nerve," designating the superior hypogastric plexus, has been established by usage, it is a misnomer for reasons which will be brought out.

## Anatomy of Superior Hypogastric Plexus

**Location: Interiliac Trigone.**—The plexus traverses, in a variable fashion, the interiliac trigone. The latter is a triangular area having its apex at the bifurcation of the aorta. Its sides are the common iliac arteries. Its base is formed by a line joining the common iliac arteries and passing anterior to the lumbosacral vertebral junction. Sometimes the base is described as a line connecting the points of bifurcation of the common iliac arteries. These two base lines may coincide, and in any case are not apt to be far apart.

This space is bounded anteriorly by the parietal peritoneum. Posteriorly, forming the floor of the space when the subject is supine, is the lower portion of the anterior surface of the body of the fourth lumbar vertebra; the anterior surface of the body of the fifth lumbar vertebra, the corresponding intervertebral disk, and the associated ligaments and fascia. Only occasionally does the uppermost part of the sacrum contribute to the floor, this depending in part on the definition of the base line. Thus, it is seen that the plexus, located in this triangle, is prelumbar rather than presacral.

Lying on, or in, the floor of this space are the left common iliac vein and the middle sacral vessels. Occasionally passing across the space are the ureter on the right and the sigmoid mesocolon and associated vessels on the left.

**The Morphology and Immediate Relations of the Plexus Itself.**—The superior hypogastric plexus lies immediately retroperitoneally in a condensation of fascia which extends across the whole interiliac trigone. This fascia with its contained plexus can be easily separated from the overlying peritoneum and from underlying vessels and parietes.

The configuration of the plexus is subject to wide variation. In fact, it seems probable that the pattern is not exactly the same in any two individuals. The arrangement varies from the rare case in which there seems to be practically one nerve trunk only, to the case in which there is a widespread network of fibers. Intermediate arrangements are the rule. Occasionally there are two more or less well-defined parallel trunks with a few intercommunicating branches. In any case the elements of the plexus are in intimate association with the fascial layer, ramifying, as they do, through the substance of this layer. From the foregoing description it is seen that the term *plexus* is preferable to the term *nerve* in designating this nervous structure.

**Connections of the Plexus.**—The superior hypogastric plexus is a part of th sympathetic division of the autonomic nervous system. It begins superiorly as the caudal continuation of the preaortic, or intermesenteric, plexus through which it is connected with the celiac ganglion. Through the connections with the latter there are many potential connections with and to various levels of the central nerv-ous system. Sensory fibers from the uterus, passing through the superior hypo gastric plexus, are said to reach the eleventh and twelfth thoracic segments of the spinal cord.

The intermesenteric plexus is usually composed of communicating bundles of nerves lying on the anterolateral aspects of the aorta. As the plexus descends, it passes on both sides of the inferior mesentery artery, and, tending to form two ap-proaching bundles, passes over the aortic bifurcation where it becomes the superior hypogastric plexus.

The lumbar sympathetic ganglia contribute fibers to the superior hypogastric plexus. Those fibers from the upper ganglia first pass through the intermesenteric plexus and those from the lower ganglia usually pass directly to the superior hypo-gastric plexus. There are also connections between the superior hypogastric plexus and the periarterial sympathetic fibers of the inferior mesenteric artery and its branches.

At the inferior portion of the plexus the fibers tend to become gathered into two more or less well-defined bundles which have been termed the inferior hypo-gastric nerves From these, nerve fibers are seen passing to the ureteral plexuses. On each side the inferior hypogastric nerve passes downward and through the uterosacral folds to join the pelvic plexus (of Frankenhäuser). The latter plexus also receives fibers from the sacral parasympathetics. Fibers leave the pelvic plexus to reach the uterus and other pelvic structures.

**Technic of Resection of the Superior Hypogastric Plexus**

There is evidence to support the belief that all the sensory fibers to the uterus pass through the superior hypogastric plexus In this, plus the accessibility of the plexus, lies the basis of the surgical removal of this structure for the relief of uterine pain

The patient is operated upon in the Trendelenburg position. The peritoneal cavity is opened through a vertical incision, preferably paramedian, the upper pole extending above the level of the umbilicus. The short or low incisions, although recommended by some, are not advised. The small intestines fall or are displaced upward and the sigmoid colon is displaced to the left when necessary. The region of the interiliac trigone is thus exposed A vertical incision through the posterior parietal peritoneum, extending from the promontory of the sacrum to the bifurca-tion of the aorta, is made (Fig. 1183). The peritoneum is then elevated on either side to the margins of the interiliac trigone (Fig. 1184). In so doing the peritoneum is easily lifted by blunt dissection from the underlying layer of connective tissue in which the plexus runs. The upper and lower attachments are clamped, and the triangular area of this neurofibrous layer is excised (Fig 1185) the extent of the excision corresponding to the borders of the trigone Though the fibers of the plexus may or may not be seen, no attempt is made to isolate these nerve fibers. This neurofibrous layer for the most part separates easily from the underlying struc-tures, but care must be taken not to injure the middle sacral vessels and the left

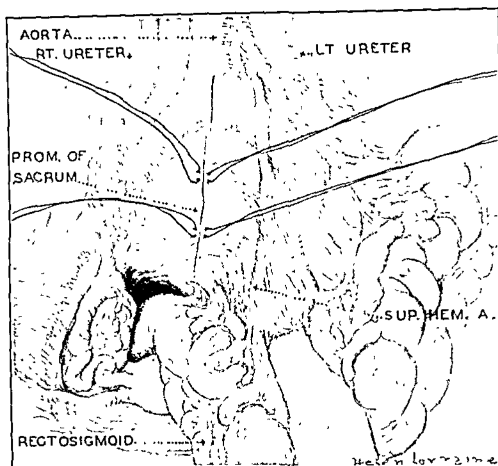



Fig. 1183.—Resection of superior hypogastric plexus The peritoneum over the interiliac trigone is exposed Four fine sutures are placed to elevate the parietal peritoneum

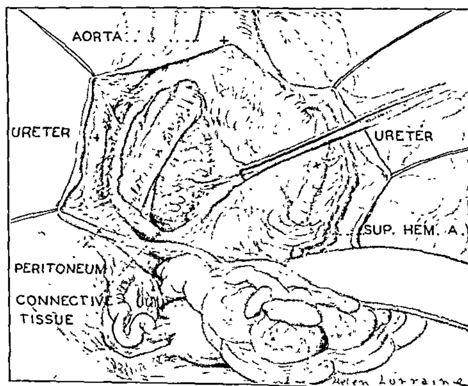



Fig 11
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iliac vein, especially the latter. The possibility of the ureter, especially the right one, lying in the field should always be borne in mind. The ureter when present in the field is usually elevated with the peritoneum. Cases in which double ureters have in part passed through the middle of the triangle have been recorded, as has the cutting of a ureter during this operation when it was mistaken for the "presacral nerve." In some cases the sigmoid mesocolon arises more medially than usual and may thus arise over the interiliac trigone. In such cases the operation

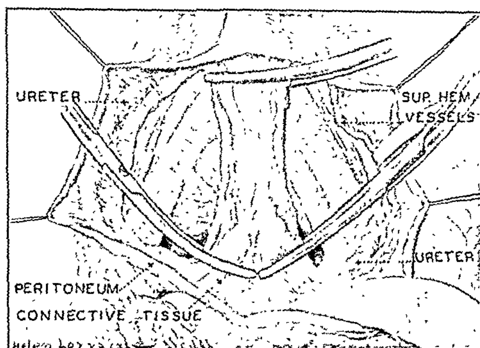



Fig. 1185.—Resection of superior hypogastric plexus. The neurofascial layer has been dissected free except at its upper and lower attachments. On these one clamp is placed above and below. The intervening tissue will be excised.

is more difficult and great care must be taken not to injure the superior hemorrhoidal artery or branches to the sigmoid colon The clamped pedicles are ligated with catgut, and the peritoneum is closed with a running suture.

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# CHAPTER 81

# THE OVARIES

RANDOLPH H. HOGE

It is a cardinal principle in medicine that the treatment of a disease should not be worse than the disease itself. In contemplating oophorectomy the possible consequences of this procedure must be considered. The removal of all ovarian tissue in the young woman, causing as it does the menopause, brings on a sequence of anatomic, physiologic, and psychic changes which may be distressing. Even the partial removal of ovarian tissue may have undesirable sequelae.

The surgeon must have an adequate knowledge of ovarian physiology and pathology; and must weigh the consequences of operations on the ovary with those of sparing it. First, the decision whether or not to operate must be made; and later, if the abdomen has been opened, a decision must be made regarding the extent of the operation, if any, on the ovary. Often the latter decision must be based in large measure on the gross findings. These findings, aided in some instances by frozen section examination, will determine largely whether or not to spare the ovary entirely, to enucleate a cyst or tumor from the ovary, to resect a portion of the ovary, to remove the entire ovary, to remove the ovary and tube, to remove both ovaries and tubes, or to remove the uterus with or without the contralateral adnexa. In choosing one of the above procedures, one must consider not only the nature and extent of the lesion, but also, in many instances, the age and pariety of the patient, and other factors.

No attempt will be made to discuss the treatment of all lesions which may occur in the ovary, but most of the indications for oophorectomy will be touched on.

## INFECTIONS

There has been in recent years a marked and laudable swing to conservatism in the treatment of the common pelvic infections. This swing has been in progress for years, but the advent first of sulfonamides and later of antibiotics gave additional force to the change, so that now mutilating operations for pelvic infection are rarely performed. This is particularly fortunate since these infections are most common in young women

Infections of the ovaries are usually secondary to infections of the tubes, but may occur by extension from other contiguous organs, or be metastatic These infections will usually subside on conservative treatment without necessitating operation. When, and if, in later stages of pelvic infection, operation is indicated, the ovaries can usually be salvaged completely or partially. An ovary may be badly

infected and yet capable of recovery. If salpingectomy is indicated, the tube in most cases should be carefully separated from the ovary and, if possible, the ovary left in situ with intact blood supply. Here again the nature and extent of the disease, the age of the patient, and the condition of the contralateral ovary will be determining factors.

### Nonneoplastic Cysts

In discussing the indications for oophorectomy it is essential to distinguish between the very common retention cysts and the less frequent true neoplastic cysts properly known as cystomas. The retention cysts are nonproliferative and are not true neoplasms. They rarely reach large size, and symptoms are apt to be absent or minor. These cysts usually disappear spontaneously and rarely call for operation. They are most frequent in young women, and in young women the danger of ovarian malignancy is less. Therefore, it is usually safe and wise to observe rather than operate upon young women for the treatment of such cysts. When and if the patient is operated upon, the surgical procedure should be conservative. In such cases the small cysts may be left alone or punctured; medium-sized or larger cysts may be enucleated. Occasionally an involved portion of the ovary may be resected, but this is seldom indicated, and rarely should the entire ovary be removed in the treatment of this condition. Wounds left in the ovary, if of sufficient size, should be sutured with fine catgut on an atraumatic needle.

## BENIGN NEOPLASMS

Benign neoplasms include dermoid cysts, pseudomucinous cystadenomas, serous cystadenomas, fibromas, and Brenner tumors. These tumors usually call for the complete removal of the involved ovary; but in some instances, especially in young women and when there is bilateral involvement, resection or enucleation can and should be done, leaving adequate ovarian tissue intact.

Dermoid Cysts.—These cysts tend to occur in young women and are bilateral in about 12 per cent of cases. In such cases enucleation of the tumor on one or both sides is the treatment of choice. This almost always can be done satisfactorily, leaving adequate ovarian tissue behind, even in those cases where it is spread out over the tumor. We have had pregnancy follow the removal of large bilateral dermoids treated in this fashion In older women there is less compelling reason to conserve ovarian tissue, and unilateral oophorectomy is justified. Bilateral oophorectomy for bilateral involvement should be used only in women who have reached or closely approached the menopause.

Pseudomucinous Cystadenomas.—In young women with only one ovary involved, the treatment is complete removal of that ovary with or without unilateral salpingectomy In young women who have bilateral tumors (20 per cent of cases) an attempt may be made to conserve ovarian tissue on the side where the tumor is smaller. However, this is not without some danger, because of the risk of unrecognized malignancy in the tumor and because of the risk of spilling and consequent production of peritoneal myxoma, or the dissemination of malignant cells. All patients treated with less than bilateral oophorectomy should be carefully followed for the new development or recurrence of tumors.

In older women both ovaries should be removed if involved, and in women at or beyond the menopause the contralateral ovary should be removed even if it is not grossly involved. In these women any suggestion of malignancy should indicate the complete removal of the uterus also.

In all cases care should be exercised not to spill the tumor contents.

**Serous Cystadenomas.**—The foregoing discussion regarding the treatment of pseudomucinous cystadenomas also applies in general to serous cystadenomas. But it must be remembered that the latter tumors are more apt than the former to be or to become malignant. Therefore, these tumors should be regarded with more suspicion, and somewhat more radical treatment may be indicated.

**Miscellaneous Benign Tumors.**—Fibromas are usually unilateral and in rare instances are associated with ascites and hydrothorax. It is important to realize that peritoneal and pleural fluid does not necessarily mean malignancy or inoperability. Moreover, the tumor itself must be distinguished from certain solid tumors which are malignant. The treatment is usually unilateral oophorectomy.

Brenner tumors are rare solid benign ovarian tumors in which unilateral oophorectomy is indicated.

## MALIGNANT TUMORS

Various types of malignant tumors will be discussed separately, but it should be realized that there are tumors on the borderline between malignancy and benignancy, and that also the degree of malignancy varies considerably from one group to the next and often within each group.

The frequency of bilateral ovarian involvement, of extension to the tube and to the uterus, and of distant metastases, is an additional pathologic factor which plays a part in the selection of treatment in malignant ovarian disease.

Because the lymphatic drainage is chiefly via vessels accompanying the ovarian blood vessels and passing to inaccessible glands in the aortic and other regions, lymphatic dissection is rarely, if ever, indicated in the treatment of ovarian tumors.

In general, the treatment of choice of malignant ovarian tumors is radical removal, which in most cases means bilateral salpingo-oophorectomy and total hysterectomy. However, there are a few tumors of low malignancy which, when occurring in young women, may justifiably be treated less radically in order to conserve ovarian and childbearing functions

**Carcinoma.**—Ovarian carcinoma is fairly common but occurs rarely before the age of thirty. The incidence increases with advancing age, and after the menopause well over half of ovarian tumors are carcinomatous. Hence, while one is usually justified in observing a young woman with an ovarian mass, palpation of a similar mass in an older woman should indicate undelayed operation. The serous cystadenocarcinomas are most common and occur much more frequently than the pseudomucinous type.

The treatment, when possible, is total hysterectomy and bilateral salpingo-oophorectomy; this is said to be feasible in 60 per cent of the cases. Even when all of the gross tumor cannot be removed, its partial removal may be of benefit. Postoperative x-ray therapy seems to be of value both in the apparently adequately and in the inadequately surgically treated cases. If the uterus has been left in,

intrauterine radium therapy also may be of value. As a whole, the prognosis is bad, five-year salvage occurring in less than a third of the cases.

**Malignant Teratomas.**—The treatment of these tumors is the same as that of carcinoma.

**Special Tumors Usually of a Low Degree of Malignancy.**—The tumors to be discussed here are the granulosa cell tumor, the arrhenoblastoma, and the dysgerminoma. The first two are hormone-secreting tumors. The third, though related, probably does not secrete a hormone. They all tend to be of a low degree of malignancy, though there are exceptions to this, especially in the case of dysgerminomas.

If a granulosa cell tumor is well encapsulated and occurs in a young person, the accepted treatment is unilateral salpingo-oophorectomy. If there is evidence of extension, or if the tumor occurs in older women, bilateral salpingo-oophorectomy and total hysterectomy are usually indicated.

The treatment of arrhenoblastoma is essentially the same as that of granulosa cell tumor.

The treatment of dysgerminoma is in general that of granulosa cell tumor and arrhenoblastoma. However, the selection of treatment for the individual case should be influenced by the knowledge that some of these tumors are exceptionally malignant, that they are often bilateral, and that frequently unalterable sterility is already present.

**Metastatic Tumors.**—The ovary is fertile soil for metastatic tumors from the other pelvic organs and from distant sources. The Krukenberg tumor, secondary to carcinoma in the upper gastrointestinal tract, is a well-known example of the latter. The possibility that a malignant ovarian tumor, especially if bilateral and solid, may be secondary must be borne in mind by the operator, and a possible primary focus sought. Even if the tumor is secondary to remote carcinoma, the removal of the ovaries may be of value.

## ENDOMETRIOSIS

There are at least two conditions in which bilateral oophorectomy may be done because of its possible secondary effect on lesions which do not necessarily involve the ovaries themselves. One of these is carcinoma of the breast in young women; this will not be discussed here. The other is endometriosis.

The treatment of endometriosis may be one of the more difficult problems in gynecology. Inasmuch as the disease process in this condition is dependent on ovarian function, the disease can be cured by elimination of this function through surgical castration or by irradiation. Such treatment may not be objectionable in a woman approaching the menopause, but in a younger woman, especially in one who has not had children, such treatment is to be avoided if possible.

Endometriosis per se is not necessarily an indication for surgery. This will depend, in the individual case, on the location and extent of the lesion, the severity of symptoms, and other factors. Though there is no satisfactory specific medical treatment of this condition, simple analgesics may prove adequate to control symptoms, and pregnancy, if possible, exerts a beneficial effect. With such treatment it is often possible to avoid or delay surgical intervention.

When surgery is required in the younger women, it is better in the great majority of cases to do an incomplete operation rather than remove both ovaries This is true even though one thereby runs the risk of incomplete relief of symptoms and the possibility of the need for additional surgery later. But more often than otherwise, if symptoms persist, they can be controlled by analgesics or through the use of irradiation. The latter is necessary only in a small minority of cases but is usually preferable to a second operation. It may be effective in subcastration dosage, and such dosage can be tried first if irradiation is indicated.

If both ovaries are involved, the one with greater involvement may be sacrificed and the other treated conservatively by resection. Small areas of ovarian endometriosis may be destroyed by excision or electrocoagulation, and similar areas elsewhere in the pelvis may be similarly treated, provided they are properly situated for such treatment.

Occasionally both ovaries will be the site of enormous chocolate cysts, and in almost all such cases bilateral oophorectomy is mandatory despite the age of the patient. Constricting lesions of the rectum may make similar treatment necessary.

Some have advocated hysterectomy with conservation of the ovaries as the treatment of choice in younger women when oophorectomy would otherwise be necessary. Among reasons given for this is the theory that hysterectomy results in gradual lessening of ovarian activity, with in such cases a resulting amelioration in the endometriosis Another theoretic explanation is that hysterectomy removes the normally placed endometrium and thereby breaks a "pituitary-ovarian-endometrial relationship." The wisdom of this form of treatment has not been established beyond question. Of course, this does not refer to the treatment of cases of adenomyosis of the uterus. The latter condition may require hysterectomy or adenomyomectomy. In some instances of uterine adenomyosis, where conservation of the menstrual and/or childbearing function is sufficiently important, resection of the superior hypogastric plexus may be indicated solely for the relief of pain.

## DISPOSITION OF HOMOLATERAL TUBE

Indications for various types of operations of the ovary have been discussed in the foregoing paragraphs.

Regarding the disposition of the homolateral tube if an oophorectomy is done, it can be said again that at the very least this tube should always be removed in the treatment of malignant ovarian disease. Furthermore, in general, the homolateral tube should be removed if it is itself in any way diseased, or if the patient does not desire or is incapable of having more children. In the absence of malignant disease, the homolateral tube should be left if the contralateral tube is diseased, provided that more children are desired and pregnancy seems possible.

## TECHNIC OF RESECTION OF THE OVARY

The ovary is elevated in the palm of the left hand with the mesovarian passing between the index and middle fingers (Fig. 1186). Then with a scalpel in the right hand the portion of the ovary to be removed is excised, usually with a wedge incision The ovarian wound is then closed with one or two layers of continuous 00 chromic catgut sutures, depending on the depth and extent of the wound.

## TECHNIC OF ENUCLEATION OF CYST OF OVARY

The ovary is held as described previously and an elliptical incision is cautiously made through the thinned-out ovarian tissue about the cyst (Fig. 1186). This incision runs near the base of the cyst as the latter merges with the remainder of the ovary. Then with the handle of the scalpel, used in blunt dissection, the cyst is enucleated intact from its bed. The ovarian wound is then closed as described.

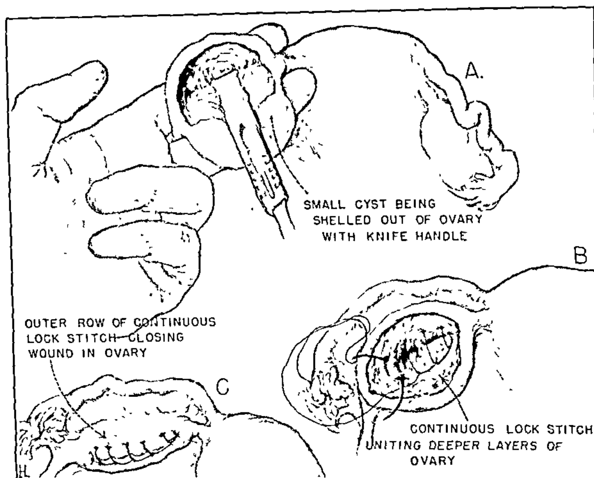



Fig 1186.—Enucleation of ovarian cyst *A*, The mesovarium is held between fingers. An elliptical incision is made through thinned-out ovarian tissue. The cyst is enucleated intact *B*, A continuous suture closes the deeper parts of the wound. *C*, A running stitch on the surface completes the closure.

## TECHNIC OF OOPHORECTOMY

The ovary is elevated and clamps are placed in continuity across the mesovarium. The mesovarium is then incised on the ovarian side of the clamps, removing the ovary. The tissues in the clamps are then ligated for hemostasis and the wound is peritonealized

## TECHNIC OF SALPINGO-OOPHORECTOMY

The tube and ovary are elevated, and the infundibulopelvic ligament with its enclosed ovarian vessels is exposed, doubly clamped, and tied then or later with a double ligature of No. 1 chromic catgut. Care is taken to identify and avoid injury to the ureter (Fig. 1187). A double row of clamps are then placed in con-

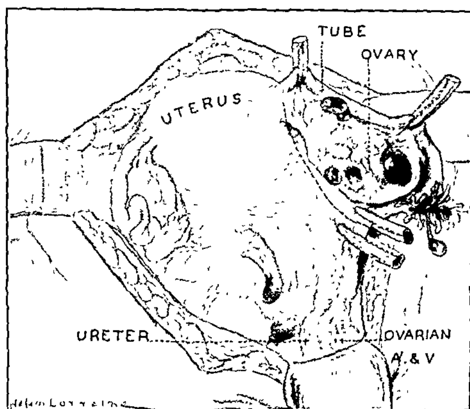



Fig 1187.—Salpingo-oophorectomy. The tube and ovary are elevated. The infundibulopelvic *ligament containing the ovarian vessels has been doubly clamped* The *ureter* has been identified and avoided The broad ligament is incised along the broken line between a double row of clamps.

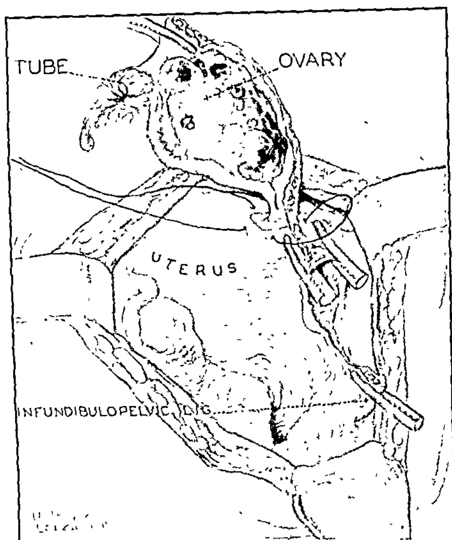



Fig 1188—Salpingo-oophorectomy. The broad ligament has been incised between a double row of clamps placed inferior to the adnexa. A figure-of-eight suture is placed deeply in the uterus about the site of tubal attachment. A wedge of cornu is excised along the dotted line.

# CHAPTER 82

# THE FALLOPIAN TUBES

Randolph H. Hoge

## INDICATIONS FOR OPERATIONS ON THE FALLOPIAN TUBES

Among the indications for operations on the fallopian tubes are inflammations, malignant tumors, ectopic pregnancy, and the production or correction of sterility. Whether the operation is limited to the one tube, is bilateral, or involves other structures also, will depend upon the condition treated and on other circumstances.

## INFLAMMATIONS OF THE TUBE

As is now well known, the treatment of salpingitis has been becoming more and more conservative for a number of years This was apparent even before the advent of the sulfonamides and antibiotics, which proved so increasingly efficacious in the treatment of this disease. The result of this conservative trend is that there are many fewer operations for the relief of salpingitis. Now operations in this disease are required much less frequently and are not done at all in the acute stages, except occasionally to drain an abscess. Furthermore, fewer patients have residual disease to require later operation However, a few cases are seen in which chronic pyosalpinx, hydrosalpinx, or tubo-ovarian abscess, with associated adhesions in most instances, is an indication for surgery In these cases it is salpingectomy or salpingo-oophorectomy which is usually indicated, and, as the condition is usually bilateral, the surgery is generally bilateral also. Only in the minority of cases should the ovary be removed, even if infected This is true because in the majority of cases the disease occurs in young women in whom castration, partial or complete, is to be avoided, and furthermore because infection in an ovary left behind will almost invariably subside, leaving a functioning and asymptomatic organ. Nevertheless there are cases in which the ovary is so badly diseased or its blood supply so damaged by disease and/or surgery that its removal seems necessary. In these cases, of course, there is even more reason to conserve the other ovary, if possible The closer the patient is to the natural menopause, the less important is the conservation of ovarian tissue.

If the pathologic condition is so great that both tubes and ovaries must be removed, then it is usually wise to remove the uterus also, as a functionless potentially troublesome organ.

Tuberculosis of the tube is now an indication for salpingectomy and the simultaneous removal of any other tuberculous genital organ, but it may be that chemotherapy or antibiotic therapy now being or to be developed will make this unnecessary in cases where conservative therapy is to be desired.

## MALIGNANT TUMORS OF THE TUBE

The tube may be the site of primary or secondary carcinoma. The former is a very rare disease in this organ. In either case the treatment, if the condition is operable, is bilateral salpingo-oophorectomy and total hysterectomy, similar to the surgical treatment of most cases of carcinoma of the ovary and of carcinoma of the endometrium. Postoperative irradiation is desirable.

## TUBAL PREGNANCY

As the operations for salpingitis have become less frequent, tubal pregnancy has become a relatively more frequent indication for salpingectomy. The sooner the operation is done, the better; and if rupture has occurred, transfusion of blood and operation are urgent. On opening the abdomen the uterus is immediately grasped and elevated, and clamps are applied to the tube to control the bleeding. The tube is removed as described below. It is rarely necessary to remove the ovary, and care should be taken not to jeopardize its blood supply. The contralateral tube should not be removed unless it is diseased to the point of being functionless, or unless sterilization is desired.

## TECHNIC OF SALPINGECTOMY

After the pelvic organs are investigated, the tube is released from adhesions, if such are present, and brought well into view. Allis clamps may be applied to the tube to elevate it, if its condition permits. Then a double row of Kelly clamps are placed on the mesosalpinx, and the latter is cut, freeing the tube to its uterine attachment. Care is taken to avoid, so far as possible, blood vessels to the ovary. Then the tube is elevated and, while traction is applied to it, a deep figure-of-eight suture is placed in the uterine cornu but not tied. Within the site of suture a wedge of uterine tissue is then removed at the uterotubal junction, and quickly following this the suture is tied, controlling bleeding and closing the uterine wound. The round ligament, with the adjacent portion of the broad ligament, is then sutured over the uterine wound as described in Fig. 1195, *D*.

If the ovary is to be removed with the tube, the technic is as described in the chapter on the ovary (Figs. 1187-1189).

## OPERATIONS FOR CORRECTION OF STERILITY

Operations solely for the correction of sterility due to occlusion or absence of the tubes may be performed, provided that no other uncorrected cause of sterility is present in the patient, the patient is in the childbearing age, is a good surgical risk, there is no infection in the genital tract, and the husband is fertile.

The patient should be informed of the generally poor results obtained and of the frequency of complications. Greenhill, in an analysis of 818 collected cases of plastic operations for the correction of sterility, showed that only 54 pregnancies (one for every fifteen operations) resulted. Ten of these pregnancies ended in abortion, and eight of them were ectopic pregnancies. Only 33 live babies were delivered, this being one live baby for every 22.5 operations. Such figures should deter one from recommending these operations to patients; but, if aware of the poor results and the dangers, a patient still wishes the operation, then it may be

done if there are no contraindicating factors. One more readily does these procedures when incidental to some other more important indication for laparotomy.

Before recommending the operation, if at all, the tubes must be known to be absent or occluded. This may be determined by the Rubin test and in some instances by salpingography. The latter procedure has the advantage of localizing the site of obstruction, but this site can be determined at the time of operation without salpingography.

Results are more satisfactory when the occlusion is at the distal end and there only. Here release of adhesions (salpingolysis) and/or incision (salpingostomy) with or without resection are the operations performed. In doing salpingostomy a cuff or flaps of the distal portion are turned back for a short distance over the tube (Fig. 1193) and sutured there.

When the obstruction is in the mid portion of the tube, the site of obstruction, with all of the tube distal to it, is removed, and a salpingostomy is performed at the distal end of the remaining portion of the tube.

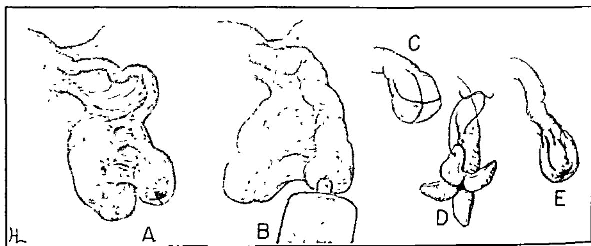



Fig 1193.—Salpingostomy Adhesions will be released and the distal end of the tube incised (*A*). A syringe tip, preferably tapered, is inserted (*B*), and normal saline solution is injected to rule out obstruction elsewhere Then the cruciate incision is enlarged (*C*), forming four flaps which are sutured with fine catgut to the serosa (*D* and *E*).

If the isthmus or the cornual portion of the tube is obstructed and the remainder of the tube is capable of function, the uterine cornu and the diseased part of the tube are resected and the distal part of the tube is implanted into the uterine cavity.

When the tube is absent, or when it must be removed on account of disease, the operation described by Estes may be done. In this operation the cut surface of an ovary, still attached to its pedicle, is implanted upon the cut surface of the uterus, where the uterine cornu has been resected, and sutured there. However, as has been pointed out by Te Linde, it would seem more logical not to section the ovary but to leave the follicle-bearing cortex intact and in contact with whatever lumen is present.

## STERILIZATION

Practically all of the operations performed on women for sterilization in the absence of disease of the genital organs are procedures which, in one way or an-

other, obstruct some part of the fallopian tube. However, disease or dysfunction of the uterus or ovaries may make, in a few instances, the removal of one or more of these organs, especially the uterus, the more desirable procedure for sterilization.

The indications for sterilization may be physical, mental, or, in the view of some, even economic. In considering them due attention should be given to the religious and medicolegal aspects of the subject. However, inasmuch as it is beyond the scope of this work to discuss the latter or to give the specific indications, the reader interested in this information is referred to the list of references on the subject.

Hewitt and Whitley state, "There are 26 methods by which the female may be sterilized." According to Dickinson and Gamble, "Combinations and variants in methods of approach, of resection of the fallopian tubes, of crushing and of burying and of cautery have put into the literature at least 3,500 titles, covering some 43 procedures for obstructing the oviducts." The approach may be abdominal, vaginal, inguinal, or through the uterine cavity. The tube may be closed by ligation of a loop with or without crushing, or by resection and ligation, or by cornual resection and suture, or by burial of the fimbriated end or a proximal cut end in various sites, or by cauterization. The burial of the abdominal ostium between the leaves of the broad ligament, as described by Aldridge, has the feature of reversibility and therefore may be advantageous in rare cases where temporary sterilization is indicated.

In most cases the abdominal route is used, and the simplest procedures are done.

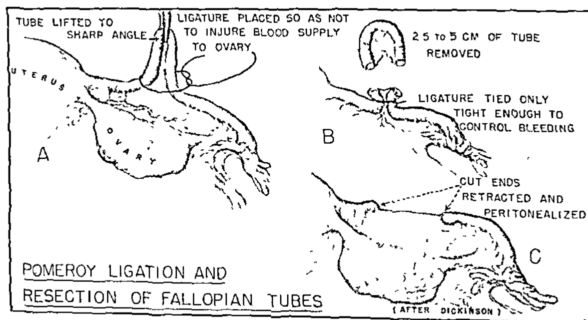



Fig 1194—Pomeroy ligation and resection of fallopian tubes

## Technic of the Pomeroy Operation of Tubal Ligation and Resection

One of the simplest and most popular methods of sterilization is the Pomeroy operation or some modification of it. It seems especially suitable to postpartum cases. The middle of the tube is lifted to form a loop of tube 2.5 to 5 cm. in length (Fig 1194, *A*). A heavy absorbable suture is then tied around the base of the loop,

and the loop is excised, leaving adequate stumps to prevent the tie from slipping off (Fig. 1194, *B*). The tie should be tight enough to control bleeding but not tight enough to cut the tube. *Furthermore, the tie should be placed so low that mesosalpinx is visible above the tie and yet not placed low enough to include any important blood supply to the ovary.* The ligature is soon absorbed and with time the ends seal and separate (Fig. 1194, *C*).

## Technic of Cornual Resection

Cornual resection is our method of choice for sterilization in cases that are not post partum. In it a segment including the proximal portion of the tubal isthmus and the interstitial portion of the tube is removed (Fig. 1195). The operative site may be brought into view by traction on an Allis clamp or ligature placed on the round ligament. Two Kelly clamps are placed on the tube about 2 cm. distant

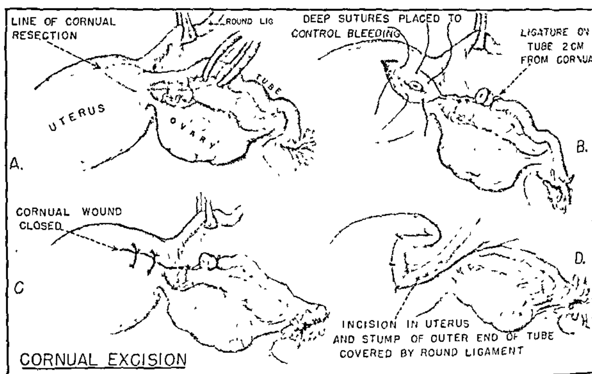



Fig. 1195.—Cornual resection for sterilization.

from the cornu and the tube is cut between the clamps. A catgut tie is placed around the tube lateral to the distal clamp, and this clamp is removed. Traction is then placed on the proximal clamp, elevating the medial part of the tube. The mesosalpinx of this part of the tube is clamped, cut, and ligated, avoiding injury to vessels which might supply the ovary. Then, with the proximal tubal stump still elevated, a wedge excision of the uterine cornu is made, the segment of tube and the wedge being removed in one piece. The uterine wound is then closed with one or two layers of No 1 chromic catgut. Following this the wound on the uterus is covered by suturing over it, onto the fundus of the uterus, a loop of the round ligament and adjacent broad ligament.

*Apparently no operation on the tube for the purpose of sterilization has proved 100 per cent successful in all hands,* but the reported incidence of failure following either of the two methods described, or modifications of them, has been low.

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# CHAPTER 83

# THE HEAD. INJURIES AND INFECTIONS

CHARLES E. TROLAND

## INTRODUCTION

The section on neurosurgical procedures is not intended to be a complete coverage of all operations performed on the central nervous system. Many operations in this specialty field are so highly technical and require so many specially designed instruments as to preclude their performance anywhere except in neurosurgical centers. Other procedures, however, should and must be carried out under emergency conditions in any hospital, and it is to this group of procedures that attention is here directed.

It is of utmost importance to bear in mind that sound surgical principles apply just as strongly to operations upon the nervous system as they do to operations on any other part of the body. Such basic principles as preservation of blood supply and the avoidance of leaving or implanting foreign bodies in infected wounds cannot be disregarded without incurring a high percentage of dire results.

## ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS

The scalp forms the covering of the skull and consists of five layers: the skin, the subcutaneous fatty layer, the galea, the areolar tissue, and the pericranium. The skin is a heavy epithelial layer and is firmly united to the galea by dense fibrous processes passing through the subcutaneous fatty layer. The nerves, blood vessels, and lymphatics are located in the subcutaneous fatty layer. The galea aponeurotica is also known as the epicranius muscle and is the tendinous extension of the occipitofrontalis muscle It blends with the temporal fascia and is thus attached to the zygomatic arches. The fourth or areolar layer is very loose, with few connections to adjoining layers, and thus allows free movement of the scalp on the pericranium. Such mobility is of great importance in closing scalp wounds where there has been loss of tissue. The pericranium is a thin, smooth layer that is attached very loosely to the cranium except at the suture lines.

The blood supply of the scalp is abundant and rich in anastomoses. The arterial supply of the frontal region is derived from the internal carotid artery by way of the frontal and supraorbital vessels, while the external carotid artery supplies the remainder of the scalp through the temporal, posterior auricular, and occipital arteries The walls of the vessels are closely adherent to the dense subcutaneous tissue which makes ligature of individual vessels very difficult. The intracranial artery of principal importance in head wounds is the middle meningeal artery, a branch of the external carotid artery This vessel enters the cranial vault through the foramen spinosum and usually forms a groove in the temporal bone.

The veins of the cranium roughly parallel the arteries, and the principal drainage is into the internal jugular and deep cervical veins. There are also many anastomoses with the dural venous sinuses which are of prime consideration in any scalp infection. The great veins of the brain drain into the dural sinuses, and over the vertex these veins have an extended course through the subdural space as they enter the superior sagittal sinus. These bridging veins are of great importance in the formation of subdural hematomas as they may be torn in any type of head injury.

Lymphatics are numerous and drain into the suboccipital, mastoid, and submaxillary lymphatic glands.

Sensation to the anterior portion of the scalp is derived from branches of the fifth cranial nerve, whereas the posterior scalp is supplied by branches of the upper cervical nerves.

The cranium itself is a bony covering completely surrounding the brain except for foramina permitting passage of the spinal cord, vessels, and cranial nerves. The vault is usually thick except in the temporal region and consists of inner and outer tables between which are diploe containing venous channels. The base of the skull is quite thin in such areas as the ethmoid and sphenoid sinuses and the orbital plates.

Any consideration of the physiology of head injuries must begin with the essential fact that the bony cranium is a closed vault. Blows on the cranium not only locally deform the skull but also send out radiating lines of force, resulting in contrecoup cerebral damage. The brain is mainly suspended within this closed vault and may be damaged immediately beneath the site of a blow or at a distance from this site by the radiating lines of force. A blow on the cranial vault also sets the brain into motion, and these oscillations may be sufficient to rupture veins crossing the subdural space into such a relatively fixed structure as a dural sinus.

## THE SCALP

### Contusions and Hematomas

Contusions of the scalp need no surgical therapy. There is usually swelling and sometimes hematoma formation, but the excellent blood supply generally causes prompt absorption. Aspiration or drainage of the usual hematoma is contraindicated because of the danger in introducing infection, but occasionally such a lesion attains huge proportions, particularly in children, and should be aspirated. Such bloody fluid collections needing aspiration are commonly subgaleal where absorption is poor. The aspiration should be done under conditions of rigid asepsis and a large needle, at least 18 gauge, should be used. Following aspiration a tight bandage should be applied as the hematoma is prone to recur.

### Lacerations

Lacerations of the scalp frequently bleed profusely, but such bleeding is usually easily controlled by digital pressure or by pressure dressings It is not feasible in most instances to grasp individual vessels as these vessels are adherent to the dense subcutanous tissue. Grasping the galea with hemostats and thus folding it back over the subcutaneous tissue will control the bleeding until closure is begun. Large vessels, such as the temporal and occipital arteries, can be ligated or coagulated but the greater part of the hemorrhage will be stopped by proper wound closure.

It should be mandatory that no scalp laceration is to be sutured until the underlying bone has been inspected or palpated. The most innocent-appearing laceration may overlay a depressed fragment or a foreign body. The additional time spent in routine inspection or palpation will avoid many of the serious sequelae of head injuries such as subdural abscess, brain abscess, and osteomyelitis.

Proper preparation of the scalp wound begins with adequate shaving, so that hair is removed to a minimum of 5 cm. from any part of the wound (Fig. 1196). In

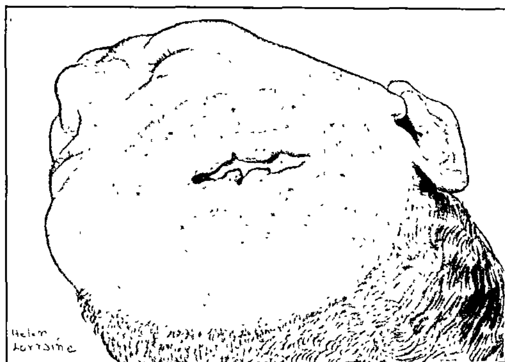


Fig. 1196.—Contused scalp laceration. The elliptical shaded band surrounding the laceration is made by application of iodine solution The lacerated scalp edges are anesthetized by the injection of procaine (1%) into the shaded area around the laceration. Disinfection and excision of the laceration may then be painlessly done.

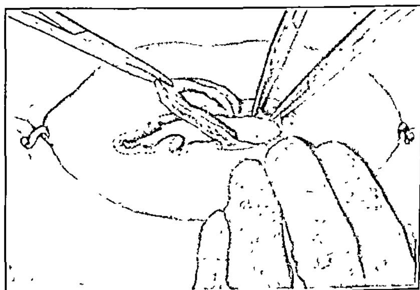


Fig. 1197 —Excision of contused scalp laceration, hemorrhage controlled by finger pressure and hemostats applied to galea Drapings in all head operations are held in position with Michel clips.

extensive wounds or those needing considerable débridement, the shaving should be more extensive and in some instances the entire scalp should be shaved. It is impossible to overestimate the importance of this shaving in avoiding infection. The skin should then be thoroughly cleansed with soap and water and painted with an antiseptic. Any antiseptic may be used, but care should be exercised not to get the antiseptic into the open wound as it only produces necrosis and thus provides a fertile bed for bacteria.

It is preferable to use local anesthesia, but Pentothal Sodium may be necessary in some intances Inhalation anesthesia should be avoided if possible as it frequently causes increased intracranial pressure. Any of the commonly used local anesthetics such as procaine may be utilized. The laceration is entirely surrounded by injecting the anesthetic into the scalp a short distance from the wound. It is important to inject the solution into the subcutaneous tissue in which the nerves course rather than beneath the galea where the sense of resistance is much less.

Sterile drapes are applied and gloves should always be worn. The edges of the wound are débrided by cleanly cutting away ragged edges and by copious irrigation with saline or Ringer's solution (Fig. 1197). Foreign bodies are carefully removed and the skull is inspected or at least palpated.

The larger vessels may be ligated, but this is not usually necessary. Closure is made in two layers with the galea being closed first with interrupted sutures of silk, cotton, or fine catgut. If débridement has been extensive, it may be necessary to utilize S-shaped, Z-shaped or other incisions to mobilize the scalp, but the great mobility of the scalp on the skull usually permits easy closure. As in all wounds, extreme tension on the suture line should be avoided, as such tension leads to necrosis. After placing the galeal sutures the skin is closed with interrupted sutures of silk or cotton. Drainage is never indicated for simple scalp wounds.

## FRACTURES OF THE SKULL

Linear fractures of the skull, no matter how extensive, are rarely of surgical interest. Simple linear fractures are never the sole indication for surgery but, viewed in conjunction with signs of extradural or subdural hemorrhage, may aid in localizing such lesions. In compound wounds the fracture line should be inspected very carefully as foreign material may have been forced into the fracture line or indeed into the cranial cavity at the moment of impact. If such foregin material is seen imbedded in the fracture line, a burr opening should be made at one end and the bone surrounding the fracture removed with rongeurs This excision need not be extensive, but all foreign matter such as hairs should be carefully removed.

Depressed skull fractures should always be elevated or removed except in instances of slight depressions over relatively silent areas of the brain, but a depressed fracture is never an indication for emergency surgery. Such operations can always wait until the condition of the patient permits a definitive procedure. The elevation of a simple depressed fracture is done to reduce the incidence of post traumatic epilepsy although it is probable that the convulsive state results from cerebral damage sustained at the time of injury rather than from the depressed bone itself. It is sound judgment, however, to remove or elevate depressed fragments as soon as the patient's condition will permit. Frequently an innocent-appearing depression cov-

ers a laceration of the dura and brain, and proper handling of such lesions will certainly reduce the amount of resulting scar tissue. In the simple fractures any type of incision can be utilized to expose the lesion and such incisions should be large enough to adequately expose the damaged area (Fig. 1198).

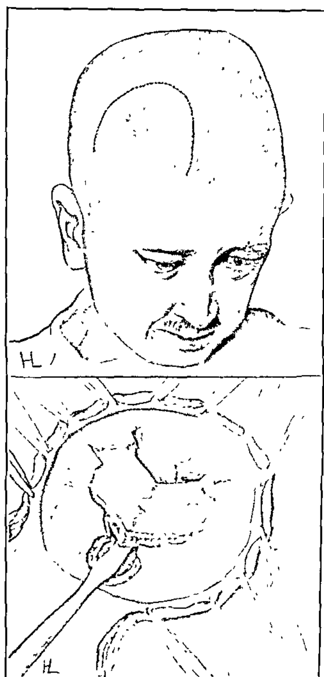



Fig. 1198.—Simple depressed fracture Depression and line of incision shown in upper drawing. Drawing below shows elevation of depressed fragments after making a trephine opening adjacent to the fracture

Compound depressed fractures are much more urgent problems and should be dealt with as soon as the patient's condition will permit. These procedures should always be carried out in the operating room with all preparations for a major case. Local anesthesia is used where possible and the scalp laceration is first débrided. Occasionally the bone fragments are loose and can be grasped with a clamp or rongeur, but usually the depressed bone is tightly wedged and cannot be grasped.

A burr opening is then made in normal bone adjacent to the fracture and the dura is exposed. A blunt instrument can then be introduced under the fragment and gentle pressure exerted to elevate the bone (Fig. 1198). It is much safer, however, to grasp the depressed fragment with a rongeur and remove it. All of the depressed fragments are removed to permit exposure of the underlying tissues. Fragments in the regions of the major dural sinuses must be handled very carefully as their removal sometimes precipitates alarming hemorrhage. Such bleeding is best controlled by the use of muscle or some hemostatic agent such as Gelfoam, which is held firmly in the bleeding area until hemorrhage ceases and is then left in place. Following the removal of the depressed fragments the dura is inspected for tears and for evidence of underlying hemorrhage. If such inspection is negative, it is sometimes permissible to mold the larger fragments back into place and then close the scalp (Fig. 1199), but it is usually a far sounder policy to remove the fragments and plan a cranioplasty if necessary at a later date. Immediate cranioplasty with tantalum or any other material should not be performed, as this practice violates the sound surgical principle of not leaving foreign bodies in potentially infected fields.

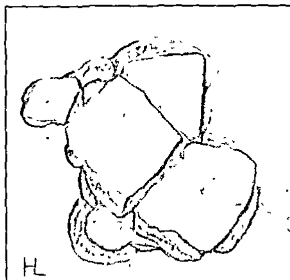


Fig 1199 —Replacement of fragments of bone in simple depressed fracture.

## Compound Fractures With Brain Damage

If the dura is found to be torn or appears blue and tense, it must be opened sufficiently to provide good exposure of the underlying brain. Subdural hemorrhage is removed by gentle irrigation and suction and, if the brain is found to be lacerated, it is also irrigated. Clots, devitalized brain tissue, and material such as bone fragments and foreign bodies are gently irrigated and suctioned away (Fig. 1200), great care being observed to obtain hemostasis by the cautery or clips. The proper care of such brain lacerations demands thorough cleansing, but this débridement must be gentle so as to spare viable brain tissue. Such proper care will greatly reduce cerebral scarring and thus lower the incidence of the traumatic convulsive state. Following the cleansing of the wound and adequate hemostasis the dura should be tightly closed (Fig 1201). Silk is the material of choice for such sutures unless the wound is grossly contaminated, when fine absorbable sutures are permissible. Drains are not used

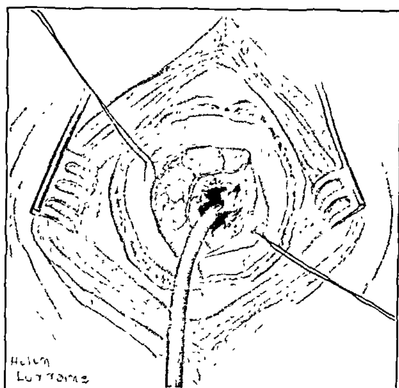


Fig 1200.—Gunshot wound of skull and brain. Method of removing blood clot and debris by irrigation and suction. A catheter is shown inserted into the brain wound. The wound made by the bullet is freely irrigated … d into the wound through a soft rubber cathet … e bulb to expand after the syringe has been em … d blood clot may adhere to the eye of the cath … d blood clot may be removed by gentle suction or in some cases in which there is extensive maceration of the brain along the course of the bullet it may be necessary to débride the brain wound through a glass tube attached to a suction apparatus.

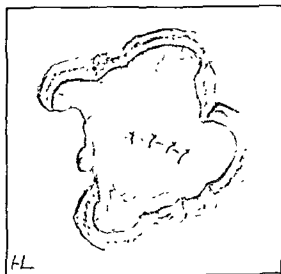



Fig 1201.—Suture of dural laceration.

The question of whether or not to apply antibiotics to the wound remains unsettled. Certainly the local application of sulfonamides or high concentrations of penicillin or other antibiotics to the brain is strongly contraindicated, as these substances are known to produce convulsions. Dilute solutions of penicillin may be locally applied and adequate dosages of available antibiotics administered systemically.

## PENETRATING WOUNDS OF THE BRAIN

Such wounds are much more common in time of war but do occur in civilian life. Early operative intervention is mandatory, as delay merely permits additional cerebral swelling with obliteration of the missile tract. Good x-ray examination is



Fig. 1202.—Lateral view of a bullet wound of the left temporal region. X-ray print shows a number of fragments of lead and bone in the substance of the temporal lobe.

essential in order to localize and enumerate the bone fragments and foreign bodies (Fig 1202). It is essential to remove the bone fragments, as retained fragments often serve as a focal point for infection. Bullets and other missiles should be removed if possible, but vital cerebral areas should not be damaged in a search for a metallic particle that probably will do no further harm.

## EXTRADURAL HEMORRHAGE

Extradural hemorrhage is usually caused by traumatic rupture of the middle meningeal artery, most frequently precipitated by a fracture through the groove of

the artery in the temporal bone. The classical clinical picture produced by this lesion is that of a blow on the head with momentary unconsciousness, followed by a "lucid interval" and then the onset of focal signs and coma Frequently, however, there is no lucid interval. Patients suspected of harboring this lesion are truly surgical emergencies as results of early intervention are well-nigh perfect whereas the late cases do very poorly. The pertinent neurological findings are normally a contralateral hemiparesis and an ipsilateral dilated pupil.

Local anesthesia is preferred, and a straight incision is made in the temporal region, extending upward and backward from the zygoma (Fig. 1203). A burr opening is made at approximately the level of the insertion of the temporal muscle, and clotted blood will begin to be extruded through this opening, which is rapidly enlarged with rongeurs to permit evacuation of the clot and control of the bleeding vessel. Good suction is essential to the location and controlling of the major bleeding vessel, which can then be ligated, coagulated, or clipped. If the major trunk of the artery has been torn, it may be necessary to expose the foramen spinosum and pack this opening with cotton, but the cautery will usually control the hemorrhage.

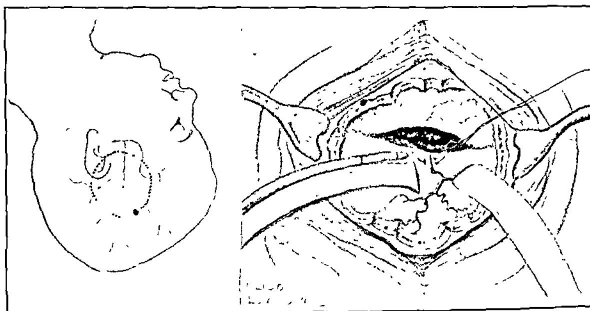


Fig. 1203.—Operation for middle meningeal hemorrhage The broken line in the sketch on the left shows the area of bone removed [illegible] The large black dot indicates the point of the initial [illegible] hemorrhage If a clot is found, the bone opening is enlar[illegible] The drawing shows ligation of the middle meningeal artery and a small residual clot below.

When the dura has been extensively stripped from the bone by a very large hemorrhage, there may be oozing from small veins, which must be sought and coagulated or sealed with some substance such as Gelfoam. In extradural hemorrhages of short duration the brain soon expands to fill the depression caused by the hemorrhage and the patient will frequently awaken at this point. In instances of longer duration the brain may remain depressed, leaving a dead space with an invitation to accumulation of another clot. Here the suturing of the dura to the periosteum or muscles at the edges of the cranial defect will promote continued hemostasis. Gardner and others have also injected saline into the spinal canal to produce expansion of the brain, with excellent results The muscle, galea, and skin are then closed with interrupted silk sutures.

Extradural hemorrhage may also occur in the posterior fossa and here its onset is more insidious than in the usual site. The cardinal symptom is increasing drowsiness and there is usually loss of tendon reflexes. Burr openings can be made over the cerebellum and the hemorrhage evacuated.

## SUBDURAL HEMATOMA

Subdural hemorrhage must be considered as two types—acute and chronic—as the problems attending each type may be quite different. Acute subdural hematomas have a bad prognosis as there is frequently extensive concomitant brain damage. The bleeding is predominantly venous, usually from tearing of a vessel crossing to the longitudinal sinus, but there may be an arterial component. The clinical picture is distinguished from that of a contusion by the rapid onset of signs of increased

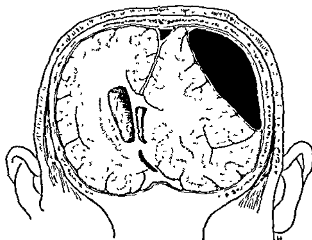



Fig 1204.—Sketch showing cross section of left chronic subdural hematoma with characteristic dislocation of ventricular system to opposite side.

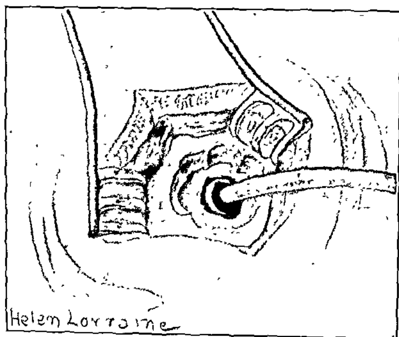



Fig. 1205—Chronic subdural hematoma. Evacuation of liquid clot through small bone opening after incision of dura and outer membrane. Removal of clot by catheter attached to suction apparatus is shown Hemorrhage is not caused by removal of the clot with gentle suction

intracranial pressure. If localizing signs are present, a burr opening is made over the indicated site and the dura is opened, permitting the escape of blood under pressure. The blood is suctioned away and the cavity flushed with saline. Not infrequently there is continued massive hemorrhage with blood welling around the cortex and the bone must be extensively rongeured away in a search for the bleeding point. If such a bleeding point cannot be discovered, the spinal injection of physiologic saline solution may be tried in an attempt to cause swelling of the cerebrum and compress the bleeding point. When no further bleeding is evidenced, the skin is closed.

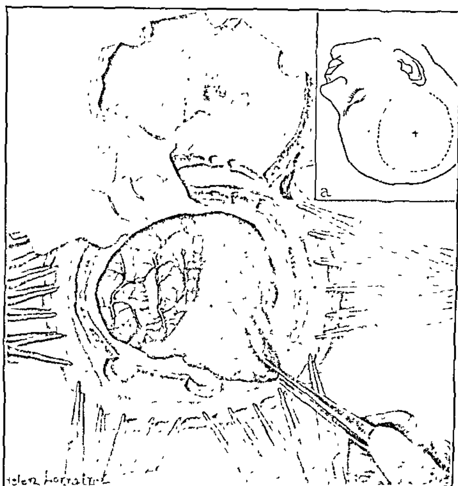



Fig 1206.—Removal of a chronic subdural hematoma The location of the incisions for the two operations most commonly used for this condition is shown in the inset. The elevated bone flap in the figure shows, near its center, a burr opening made twelve days before the flap operation The larger liquid portion of the clot was evacuated through the burr opening Persistence of symptoms led to the osteoplastic flap operation shown in the figure for the removal of the solid portion of the clot. This clot is not e[illegible] membrane which is held in the grasp of the forceps. An [illegible] of the vessels of the cortex In a large majority of cases of [illegible] is mostly liquid, and evacuation of the clot through a burr opening is all that is required [illegible] larger exposure by an osteoplastic flap may be necessary for the removal of solid clot when the symptoms are not relieved after the evacuation of the liquid portion through a burr opening.

Chronic subdural hematomas may result from relatively minor episodes of trauma to the cranium. The bleeding is venous and usually arises where veins cross to the longitudinal sinus. The breakdown of this blood gives rise to a high osmotic pressure, thereby pulling fluid into the subdural space and gradually increasing the size of the hematoma (Fig. 1204). The symptoms are therefore insidious in onset

and signs are frequently few in number. In suspected cases a burr opening should be placed in the temporal region and the dura opened. In many cases the chocolate-colored fluid will spurt from the opening and the entire fluid contents can be flushed through the single opening (Fig. 1205). In other instances the opening may have to be enlarged if the hematoma is semisolid. Rarely is an osteoplastic flap needed in an adult (Fig. 1206). If the temporal opening does not disclose a hematoma, additional openings may be made over the frontal, parietal, and occipital regions. Even if a subdural hematoma is found on the suspected side, it is mandatory to make at least one opening on the contralateral side as many of these lesions are bilateral.

Subdural hematomas in children present a different problem; in all of these hemorrhages a thick outer and thin inner membrane are formed. In the adult these membranes are of minor importance as the brain has attained its growth, but in the child the inner membrane can cause constriction and marked limitation of cerebral growth. It is therefore essential that this membrane be removed. An osteoplastic flap is reflected over the hematoma and the outer and inner membranes are carefully stripped away. The bone flap is then replaced.

## SUBTEMPORAL DECOMPRESSION

In instances of head injuries it is imperative that some relief be obtained from increased intracranial pressure that has resulted from contusion or petechial hemorrhage Such relief can sometimes be afforded by subtemporal decompression. With the advent of better methods of localizing intracranial lesions and improvements in the general care of the injured patient, this operation has been performed with increasing rarity, but it unquestionably can be of extreme value in some cases.

In the most commonly used method of subtemporal decompression a skin incision begins at the zygoma about 1.5 cm. in front of the tragus and extends upward and slightly backward for 10 cm. (Fig. 1207). The temporal fascia and muscle are incised in line with the scalp incision and retracted (Fig. 1208). An opening is made in the bone with a perforator, and burr and rongeurs are then used to enlarge the opening to about 7 cm. The middle meningeal artery is frequently torn but can be coagulated with the cautery or ligated with transfixion sutures Bony hemostasis is obtained with wax. The dura is palpated and, if tension seems to be extremely high, ventricular puncture may be attempted. Sutures may then be placed in the muscle ready for immediate tying if the cortex seems ready to rupture when the dura is opened An avascular area of the dura is elevated on a hook and incised (Fig. 1209) The dural opening is enlarged by incising it on a grooved director or spatula (Fig 1210). Radiating incisions are then made in the dura to the edge of the bony defect in order to give the maximum relief of pressure (Fig. 1211).

If tension is very high, a ventricular needle may be introduced in a search for hemorrhage. In cases of slowly developing coma usually without localizing signs, the temporal tip is frequently found to be badly contused and such contusion may be the case of the elevated intracranial pressure. The contused area can be removed by suction and cautery, as recommended by Botterell, affording an internal decompression, but this procedure should be carried out only with excellent neurosurgical facilities and by someone trained in neurosurgical procedures.

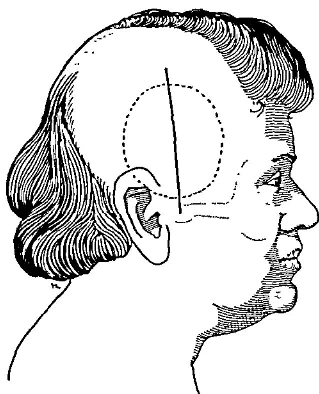


Fig. 1207.—Subtemporal decompression. Location of skin incision shown by heavy line. Area of removal of bone indicated by broken line.

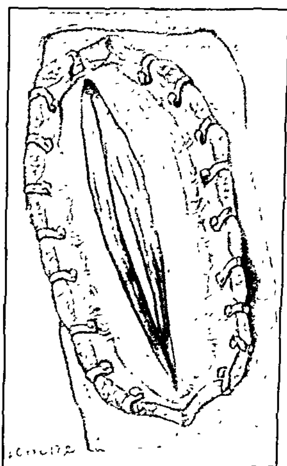


Fig 1208—Subtemporal decompression Bleeding from scalp controlled by Michel clips Incision through fascia and muscle.

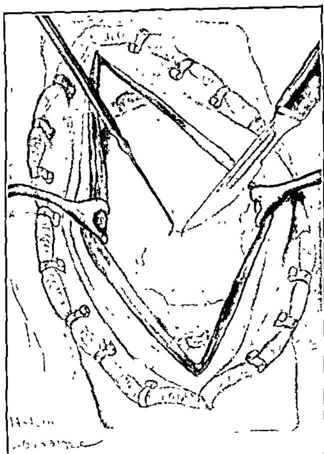


Fig 1209 —Subtemporal decompression. Incision of dura. The edges of the bone are seen in the angles of the incision.

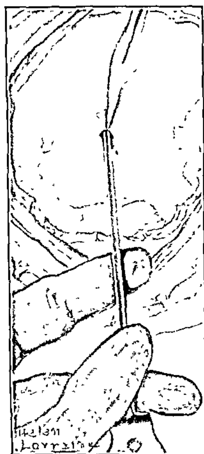


Fig 1210 —Subtemporal decompression. Enlargement of the dural incision on a grooved director.

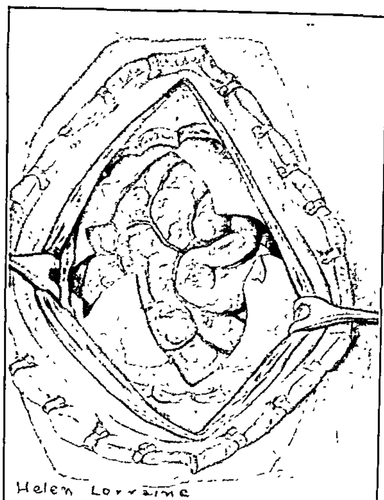



Fig. 1211.—Subtemporal decompression. Dura widely opened by radiating incisions

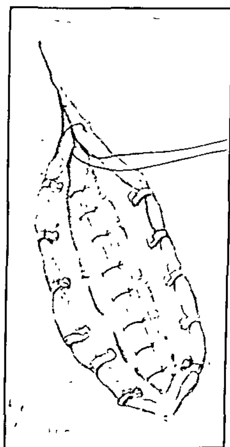


Fig. 1212 —Subtemporal decompression Closure of muscle and fascia. The galea is closed with an inverted suture

After the dura has been incised, the muscle is quickly brought together and sutured. The fascia need not be sutured in traumatic cases, but should be carefully sutured if the decompression has been done because of a chronic lesion. Relaxation incisions in the fascia may be necessary in such cases. Silk is used for all layers, and drainage is not employed (Fig. 1212).

Another method of decompression utilizes a curvilinear incision beginning behind the ear and curving upward around the insertion of the temporalis muscle and then downward almost to the outer canthus of the eye (Fig. 1213). The temporalis muscle is sectioned almost at its insertion and reflected downward to expose the entire lateral temporal bone. The bone is entered and rongeured away, revealing almost the entire temporal fossa. The dura is opened in a stellate fashion as before and the muscle then sutured. This exposure is of particular value if partial resection of the temporal lobe is contemplated.

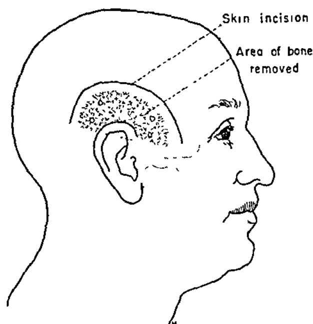



Fig 1213.—Curvilinear incision exposes temporal muscle up to its insertion After muscle has been reflected downward, the temporal bone is widely excised

## CRANIAL DEFECTS

The repair of cranial defects—cranioplasty—has been studied extensively as a result of war wounds. Many materials have been used for such repairs: ribs, steel, Vitallium, acrylic resin, and polyethylene celluloid, but it appears that tantalum is the best of present materials for this purpose This substance is strong but can be bent to almost any contour in order to obtain a well-fitting plate. It also causes only slight reaction in the surrounding tissues.

There are certain basic principles the observance of which will produce a high percentage of good results in cranioplasty. In grossly contaminated wounds, such as those resulting from the removal of infected bone, the defect should *not* be covered for at least several months after the cessation of all drainage. Even though the immediate plating of infected bony defects has been advocated, such a violation of the cardinal principle of good surgery will necessitate the removal of the plate in many instances. It is also essential that the overlying scalp be in relatively good

condition, as thin, avascular scar tissue will not tolerate an underlying plate. It is also well to take particular care when reflecting the scalp over the defect not to enter the dura for such an injury would cause a troublesome leakage of cerebrospinal fluid.

All defects in the skull do not need to be covered. Small openings behind the hairline usually do not require attention, and this is particularly true in children, in whom the defects will frequently close in with normal growth. The major indications for operation are to correct an obvious deformity, to protect vital areas of the brain, and to abolish a feeling of insecurity in some patients. Convulsions and posttraumatic symptoms are not indications for cranioplasty.

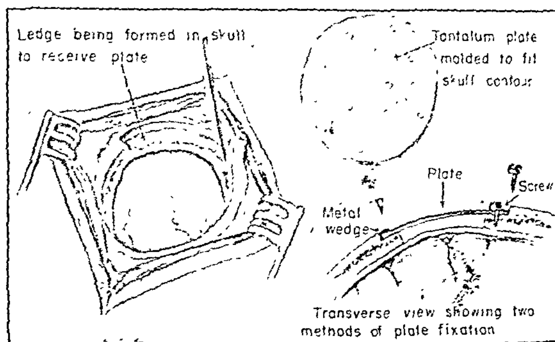



Fig. 1214.—Tantalum plate molded and perforated. Portion of outer table of skull being removed to form ledge for plate. Formation of this ledge is not usually necessary and plate can be put on as an onlay. Plate is secured with screws or wedges.

The scalp is carefully reflected from the underlying dura, care being taken not to incise the dura. A wide exposure of the bone around the defect should be obtained. The tantalum is cut to the proper size from a sheet and an accurate contour is obtained by bending and beating the metal on a wooden block. Usually the plate is put on as an onlay, but the outer table may be cut down to permit an inlay if desired in exposed areas (Fig. 1214). Small, flat-headed screws are used to secure the plate, or triangular pieces of tantalum can be cut, driven into the bone, and folded onto the plate. The scalp should be closed without drainage.

## INFECTIONS

### Scalp

The vast majority of scalp infections are localized and result from improper handling of lacerations. Adequate cleansing and drainage usually suffice to produce a cure. However, there may be a rapid spread of infection through the loose subgaleal areolar tissue, producing a marked and indeed terrifying edema of the entire scalp. Early drainage by means of multiple incisions in dependent regions is necessary and will generally lead to a rapid disappearance of the edema.

## Skull

Osteomyelitis of the skull arises from compound cranial injuries or spread of infection from the air sinuses or mastoid cells. Hematogenous origin is rare. The discovery of such bony infection is an indication for prompt surgical treatment as the present antibiotics will rarely cure or even prevent the spread of the infection X-ray changes are not present for approximately ten days after the onset of the osteomyelitis, and, therefore, edema and local tenderness must be relied upon for an early diagnosis.

Wide exposure is necessary as the infection frequently extends far beyond its presumed borders. In the frontal region a coronal scalp flap can be utilized and the pericranium reflected. A perforator opening is made through the bone, and usually pus freely exudes. A wide removal of the bone is then obtained by piecemeal removal with rongeurs. A block excision can be made, but piecemeal removal is generally preferable. The dura will be seen to be covered with dirty granulations and such granulations aid in demarcating the area of overlying infected bone. It is best to be radical and remove a small area of normal-appearing bone. Antibiotics are then applied in moderation and the scalp is loosely closed around several drains.

## Subdural Abscess

Infection may enter the subdural space by way of compound wounds but usually enters from the nasal sinuses or mastoid cells. The presence of purulent material in the subdural space has long carried a high mortality but vigorous treatment can lead to a high percentage of cures. The principal fact that has led to better results is the realization that pus frequently accumulates along the medial aspects of the cerebral hemispheres, and this region must be drained.

In suspected cases a burr opening is made in the frontal or temporal regions and the dura is opened. If purulent material is disclosed, a soft catheter is inserted and irrigation with a solution containing an effective antibiotic is carried out Numerous openings should be made and catheters placed in the subdural spaces for frequent and thorough irrigation When the purulent matter is largely localized along the falx, it may be necessary to remove a block of bone along the midline (Fig. 1215). It is essential that adequate drainage be obtained and that the infected region be frequently irrigated.

## Brain Abscess

Brain abscesses may be secondary to infection of the air sinuses or mastoid or to osteomyelitis of the skull Many abscesses, frequently multiple, are secondary to infection in other organs, particularly the lungs. The selection of the proper time for surgical treatment of an abscess is of utmost importance. All of the abscesses begin as a septic encephalitis with brain softening, causing acute symptoms. At this stage surgery is of no avail and will only spread the infection. The antibiotics should be used as soon as the infection is suspected.

Later a capsule forms around the area of infection and the central portion becomes actual pus At this stage the abscess endangers life because of increased intracranial pressure, and surgical therapy is needed. The preferred method of treatment is simple tapping of the abscess with a large needle after it has been accurately localized either neurologically or by ventriculography. Such tapping

leases the pressure and may suffice to cure the abscess. Perhaps a better method is the irrigation and drainage of the abscess (Fig. 1216). A burr opening is made and the dura opened. The arachnoid is cauterized to seal it to the pia mater and thus minimize the chance of meningitis. A ventricular needle is introduced through the overlying brain and the capsule. A soft catheter is then introduced along the needle tract and the cavity is irrigated with an antibiotic solution. The catheter is left in place and irrigated several times daily for three or four days and withdrawn when drainage ceases.

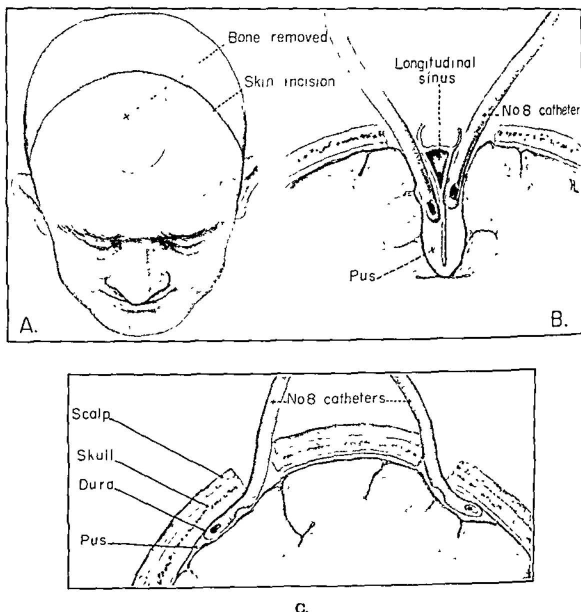



Fig 1215.—*A* and *B*, A coronal flap is reflected and bone rongeured away in the midline. Catheters are inserted on both sides of the falx to secure drainage and permit irrigation. *C*, Multiple catheters are inserted over the cortex

Sometimes the more superficially located abscesses can be exposed and the overlying cortex removed. The abscess is opened widely and packed (Fig. 1216). On other occasions when the abscess is in a relatively silent [illegible] entire abscess can be removed The conservative method of catheter [illegible] drainage is the preferable treatment.

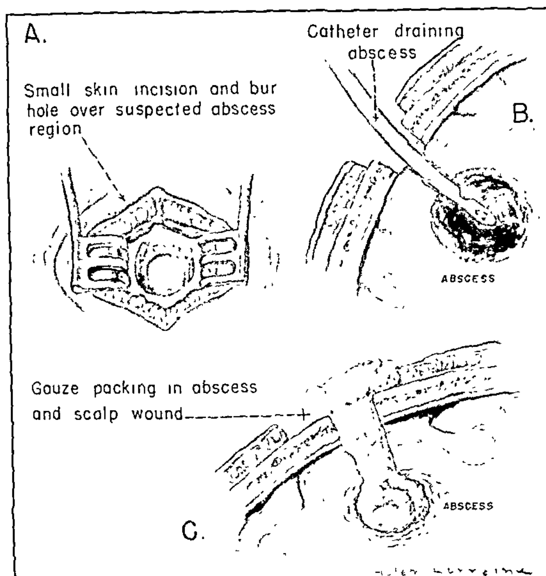



Fig 1216—A small burr opening is made over the suspected abscess and the dura is then opened. After the abscess is located, a catheter drain is placed in the cavity. In *C*, the cavity has been packed with gauze, which will be allowed to extrude. This packing *technic is* rarely indicated

## Brain Fungus

A fungus of the brain not infrequently results from an improperly treated compound fracture with dural laceration or operation for brain abscess. It is always *serious but not necessarily fatal (Fig. 1217). Adequate primary* treatment of compound wounds will nearly always prevent this complication. When it does occur, the fungating brain should be protected from pressure by a doughnut of gauze and rubber tissue placed over it to avoid adhesions to the dressing. As infection subsides, the herniation will sink back into the cranial vault and the surface will epithelize (Fig. 1218).



Fig. 1217. Fig. 1218.

Fig. 1217 —Cerebral fungus following poorly treated penetrating wound.
Fig. 1218 —Cerebral fungus receding with epithelization following conservative treatment

## GENERAL CARE OF HEAD INJURIES

The unconscious patient must be treated as gently as possible and all contemplated procedures should have therapeutic importance. Pertinent neurological information, for example, the state of consciousness, condition of pupils, and mobility of extremities, must be obtained, but a detailed neurological examination yields no useful information and may disturb the patient. Roentgenological examination is contraindicated in acute injuries but should always be obtained when the patient's condition will permit.

Adequate oxygenation is of utmost importance. The air passages must be open, as cyanosis increases intracranial pressure and may cause a fatality. The patient should usually be kept in the posttonsillectomy position with the head down so that secretions will drain out of the mouth. Suction is frequently necessary and tracheotomy may occasionally have to be performed. The maintenance of proper fluid balance is also of great importance.

Sedation is rarely needed, but when required it should consist of paraldehyde or the barbiturates and never morphine, which is a respiratory depressant.

If the patient is shocked and does not respond to blood transfusions, other injuries must be suspected, as head injuries rarely produce sustained shock. Fractures, intrathoracic hemorrhage, or perforation of a viscus may be masked by a head injury, but should be sought for if shock continues after appropriate therapy.

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## CHAPTER 84
# THE CRANIAL NERVES

Charles E. Troland

## THE FIFTH NERVE

Tic douloureux or major trigeminal neuralgia is an exceedingly e to diagnose. The history is that of lancinating, paroxysmal attacks of set off by any form of external stimulation. The pain may occur in of the divisions of the fifth nerve and is unilateral except in rare ins etiology is unknown and treatment consists of interrupting the approp fibers between the nerve endings and the pons. This may be accompl following methods: (1) alcohol injection of second or third divisions where they emerge from the skull; (2) injection or preferably avulsion o eral branches of the nerve; (3) partial or complete section of the s and (4) alcohol injection of the Gasserian ganglion. Alcohol injectio ways be done in atypical cases or whenever there is any question as to d in the majority of cases early operation seems indicated as it affords l a factor of importance in elderly patients.

### Alcohol Injection

**Third Division.**—The patient is placed on his back or side with the in the horizontal plane. The zygomatic region is cleansed and drap zygomatic arch is palpated. A small skin weal is raised with procain cm. below the notch and a 22 gauge lumbar puncture needle is inserted backward through this weal to a depth of 4.5 to 5 cm. The patient complain of lancinating pain in the tongue or lower lip when the ner although the pain may be confined to the needle area. If a typical flas produced, the needle is correctly located and 1 c.c. of 95 per cent or cohol is injected. If the pain is localized at the needle point, 1 c.c. of pr be injected, and if appropriate numbness is produced the alcohol can jected. There is a characteristic resistance to injection when the need nerve. If the needle has been inserted too far posteriorly, there will the ear and the needle must be withdrawn and inserted farther anterior

Proper injection of the third branch of the nerve produces anesth anterior two-thirds of the tongue, the lower jaw, and half of the lower motor fibers will also have been injected, the jaw will deviate to the injec

**Second Division.**—The fibers may be injected at the infraorbital fo it is far preferable to inject the second division at the foramen rotund

needle is inserted just below the zygomatic notch and directed anteriorly and upward in the plane of the external canthus of the eye and at an angle of about 115 degrees to the skin surface. The pterygoid bone is reached at about 5 cm. and the needle point is lowered to enter the pterygopalatine fossa. At an additional depth of 0 5 to 1 cm. the nerve will be entered and flashing pain produced in the upper lip, the side of the nose, and the upper jaw. A few drops of procaine will produce anesthesia, and 1 c.c. of alcohol is injected.

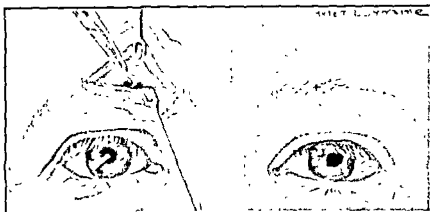


Fig. 1219.—Avulsion of supraorbital nerve.

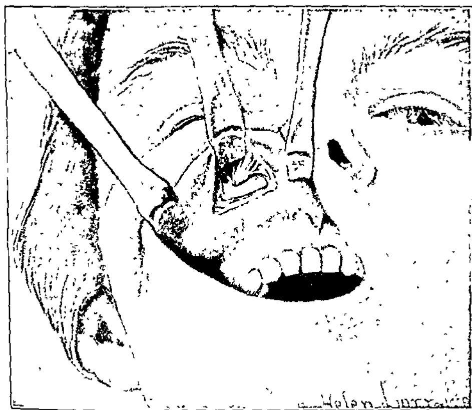


Fig 1220—Incision for resection of second division of the fifth nerve from within the mouth

Gasserian Ganglion.—European surgeons frequently inject the gasserian ganglion, but this procedure is hazardous and should never be used by inexperienced people. The ganglion may be reached just as in a third branch injection by inserting the needle 0.5 cm deeper. The hazards of the procedure, i.e., entrance of alcohol into the subarachnoid space, preclude its wide usage.

## Avulsions

**Supraorbital Nerve.**—Injection of this nerve is usually unsatisfactory and avulsion is preferred. The nerve is blocked with procaine at the supraorbital notch or foramen after the eyebrow has been shaved off. A 2.5 cm. incision is made through the eyebrow down to the bone and the nerve is identified and isolated (Fig. 1219). It is then avulsed from the foramen, removing as much nerve as possible. The wound is closed with interrupted sutures.

**Infraorbital Nerve.**—This nerve also may be injected with alcohol, but avulsion is preferable as it affords a longer period of pain relief. Local anesthesia is obtained by procaine injection at the infraorbital foramen, which is situated about 1 cm. below the lower orbital rim. The upper lip is retracted and a 3.5 cm. incision is made through the mucous membrane just above the alveolar border down to the bone. Dissection is carried upward beneath the periosteum until the foramen is exposed (Fig. 1220). The nerve is isolated and avulsed by gentle traction downward. The incision in the mucous membrane is closed with catgut sutures.

## Section of the Sensory Root

There are few if any operative procedures about which more misconceptions exist than the section of the sensory root of the fifth nerve. It is generally thought to carry a high mortality and be accompanied by a high incidence of facial paralysis and keratitis. The facts are that the mortality in experienced hands is approximately 1 per cent and the incidence of complications is low.

The most frequently used approach to the sensory root is the temporal approach and there is little doubt that this is the safest for the great majority of operators. It is performed in the sitting position under local anesthesia and the patient usually can leave the hospital in four to seven days. The short hospital stay and very early ambulation are of great importance as most of the patients are elderly.

The incision is made about 1.5 cm. anterior to the tragus and extends from the zygoma upward and slightly backward for 7 cm. (Fig. 1221). The temporal fascia and muscles are incised in the direction of their fibers and retracted, exposing the squamous portion of the temporal bone. An opening approximately 5 cm in diameter is made at the base of the skull and a small opening is made in the exposed dura to allow escape of cerebrospinal fluid. The dura is separated from the bone and the temporal lobe is elevated in order to gain access to the middle meningeal artery. There may be some bony spurs that have to be chiseled away. The artery is followed down to the foramen spinosum which is plugged with cotton.

The vessel is sectioned and any bleeding can be controlled by electrocoagulation. The sucker is an excellent instrument for further dissection of the dura anterior and medial to the foramen spinosum, and any venous oozing can usually be controlled with Cottonoid strips. The third division of the nerve can be visualized as it passes out the foramen ovale, and a white line, marking the attachment of the temporal dura to the dura propria, is seen several millimeters above the foramen. Careful incision at this line greatly facilitates the stripping of the dura to expose the sensory root floating in cerebrospinal fluid. The dura is opened to form a flap and the sensory root is retracted to expose the motor root which runs obliquely from the mesial border of the sensory root downward to join the third division (Fig. 1222). After careful isolation of the motor root the appropriate amount of the sensory root is avulsed. It is rarely necessary to section the entire

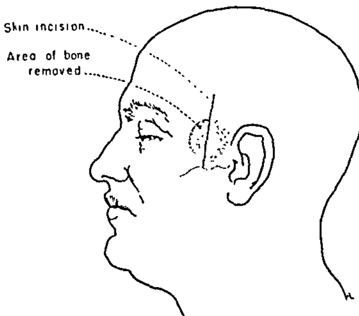



Fig. 1221.—Location of skin incision and approximate amount of bone to be removed.

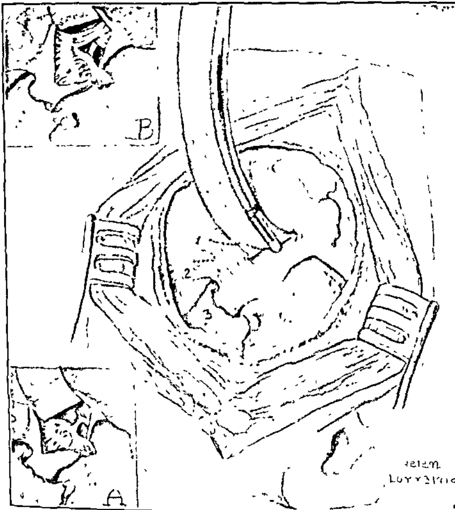



Fig 1222—Exposure of sensory root of ganglion in the operation for tic douloureux The drawing shows the elevation of the temporal dura and a cotton pledget in the foramen spinosum for occlusion of the middle meningeal artery Inset *A* shows the sensory root completely divided with the motor root preserved Inset *B*, The sensory root has been partially divided A few of its inner fibers which supply the ophthalmic division have been preserved.

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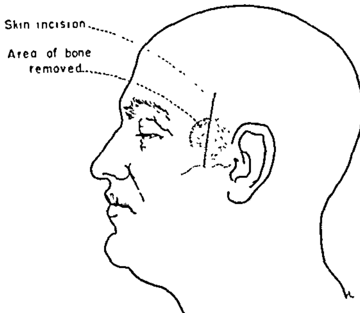



Fig. 1221.—Location of skin incision and approximate amount of bone to be removed.

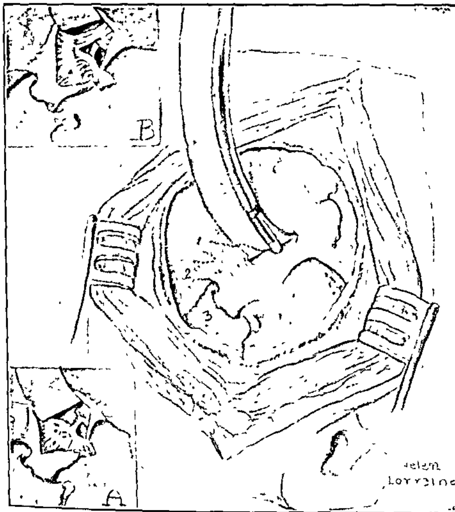



Fig 1222—Exposure of sensory root of ganglion in the operation for tic douloureux. The drawing shows the elevation of the temporal dura and a cotton pledget in the foramen spinosum for occlusion of the middle meningeal artery. Inset *A* shows the sensory root completely divided with the motor root preserved. Inset *B*, The sensory root has been partially divided A few of its inner fibers which supply the ophthalmic division have been preserved.

root, as only a relatively few cases of tic douloureux *involve the first division* and it is most important to preserve corneal sensation whenever possible A small piece of Gelfoam can be placed over the opening in the dura propria and similar thin strips can be used to control venous bleeding. The fascia and skin are closed with interrupted sutures

If the entire root has been sectioned, the eye should be protected with a shield until the patient is fully cooperative. Rarely a keratitis develops that necessitates *temporary closure of the eye.*

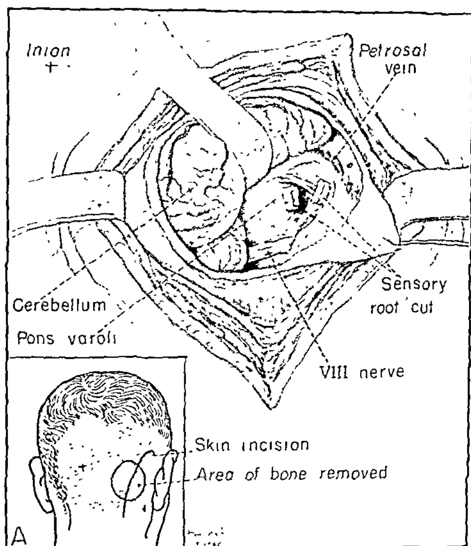



Fig. 1223.—The cisterna magna has been evacuated and the cerebellum retracted medially The sensory root of the fifth nerve has been completely sectioned, leaving the motor root intact

The root may also be sectioned by the suboccipital route as advocated by Dandy. This approach always avoids damage to the motor root.

The operation may be performed with the patient face down or sitting, but the *lateral* position *has many advantages. A straight vertical incision is* made about midway between the mastoid tip and the midline, or a curved hook incision may be used The trapezius muscle is split in the direction of its fibers and retracted, exposing the bone, which is opened with a perforator and burr. A bony opening of approximately 4 cm. diameter is made with rongeurs, its lateral edge being at the

mastoid cells. The dura is opened as a flap and the cisterna magna is evacuated. The cerebellar hemisphere is then gently retracted away from the lateral bony wall and the lateral cistern is opened. The petrosal vein is seen at the lateral edge of the tentorium and usually must be cauterized. The sensory root of the fifth nerve is visualized just below the petrosal vein and may be avulsed, but the safer method is to pick up a few fibers in the forceps and section them by cauterization (Fig. 1223). The dura is then closed and the muscles and skin are sutured with interrupted stitches.

There can be little doubt that the suboccipital approach is fraught with much more peril than the temporal approach and certainly it should never be attempted except with a complete neurosurgical armamentarium.

## THE SEVENTH NERVE

The principal function of the facial nerve is to supply motor power to the muscles of expression Paralysis of this nerve may result from (1) direct trauma such as stab wounds or injury while removing a parotid tumor, (2) trauma in the course of a mastoid operation, (3) injury while removing an acoustic neurinoma, (4) fracture through the petrous pyramid, or (5) neuritis (Bell's palsy). Such paralysis is very disfiguring and must be overcome whenever possible.

### Direct Suture

Complete or partial facial paralysis following an injury in the parotid region is an indication for early operation. The wound should be extended to facilitate discovery of the nerve ends, which are approximated with one or more fine silk sutures. The use of electric current will frequently aid in the discovery of fine branches.

### Anastomosis

If the nerve has been destroyed intracranially some type of anastomosis is indicated. The central end of the hypoglossal (Fig. 1224) or spinal accessory nerves is sutured to the peripheral end of the facial nerve. There is some evidence that suturing small bundles of the central end to individual branches will produce better functional results with less mass movements

An incision is made from the tip of the mastoid downward just below and parallel to the mandible. The platysma and part of the sternomastoid muscles are divided and the hypoglossal nerve is located where it passes over the cornu of the hyoid bone The nerve is dissected upward toward the tongue. The facial nerve is then located, one method being to identify the branch going to the digastric muscle and following it upward to the trunk (Fig. 1225). The facial nerve is divided and pulled downward in order to estimate the required length of hypoglossal nerve, which is then sectioned. The central end of the hypoglossal is anastomosed without tension to the distal end of the facial nerve (Fig 1226) or its branches (Fig. 1227) with fine silk sutures. The wound is closed in layers and no restraining dressings are necessary.

The spinal accessory nerve is often used instead of the hypoglossal, the nerve being located by an incision along the anterior border of the sternomastoid muscle and sectioned as it enters that muscle.



Fig. 1224.—Faciohypoglossal anastomosis. Sketch shows branches of facial nerve. Incision indicated by heavy line parallel to lower border of mandible.

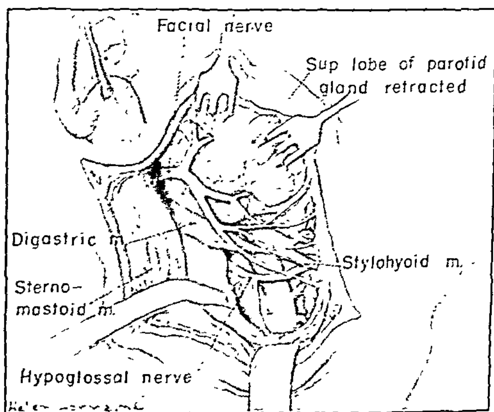



Fig 1225 —The trunk and branches of the facial nerve have been exposed. The hypoglossal nerve is identified after the jugular vein is retracted. The spinal accessory nerve can be used and is found by a similar exposure and retraction of the sternomastoid muscle.



Fig 1226.—Faciohypoglossal anastomosis. The trunks of both nerves have been divided and sutured beneath the digastric muscle Two or three lubricated fine silk sutures are usually required The peripheral stump of the hypoglossal is seen beneath the styloglossus.

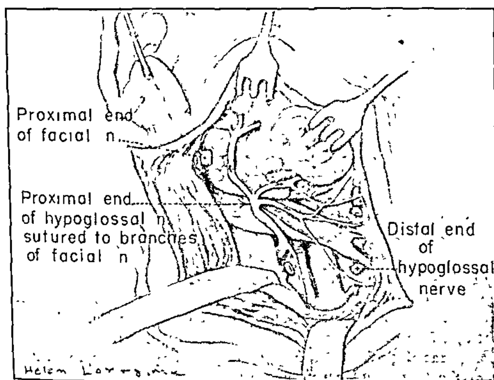



Fig. 1227 —The hypoglossal nerve has been sectioned and divided into discrete bundles that are sutured to individual branches of the facial nerves

These procedures do not give perfect results but do afford a marked improvement over a paralysis (Figs. 1228 and 1229).

## Nerve Graft

Grafts of the anterior femoral cutaneous nerve may be used with good results when there has been a loss of nerve substance during a mastoid operation. The facial nerve ends are exposed above and below the injury in the facial canal and the graft is laid in so that it contacts these endings. Sutures are not necessary as the graft fits well into the canal. Excellent results may be obtained even in the presence of some infection.



Fig. 1228.



Fig 1229

Fig 1228 —Photograph of patient with right facial paralysis following mastoid operation

Fig. 1229 —Same patient as shown in Fig 1228, six months after faciohypoglossal anastomosis. Muscular contraction about the mouth and eye seen

## Facial Spasm and Blepharospasm

Most cases of facial spasm are mild but occasionally may be annoying and disfiguring enough to warrant operation. Individual muscles or the entire side of the face may be involved and rarely there is bilateral spasm (Fig 1230). It is essential that the patient be made to understand that operation necessarily means at least a partial paralysis. Alcohol injection of the trunk of the nerve may be used (Fig. 1231) but operative section is usually preferable (Fig. 1232).

In major facial spasm the incision begins at the zygoma approximately 1 cm. in front of the tragus and curves under the pinna. The trunk of the nerve is located, divided, and sutured. If the spasm has been localized to one muscle group, the appropriate fibers are identified by stimulation and sectioned. Spasm may well recur when the nerve regenerates and if such is the case a spinofacial or hypoglossofacial anastomosis is indicated.



Fig. 1230.



Fig. 1231

Fig 1230.—Photograph of patient showing bilateral facial spasm. During attacks patient was unable to open eyes.

Fig 1231.—Same patient (Fig. 1230) after alcohol injection of left facial nerve.

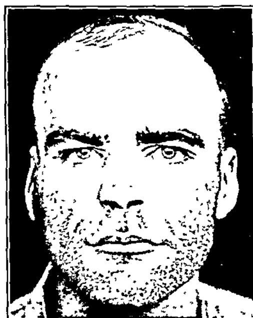


Fig 1232—Same patient (Fig 1230) after production of bilateral facial paralysis for relief of bilateral facial spasm The right facial nerve was sectioned and then sutured.

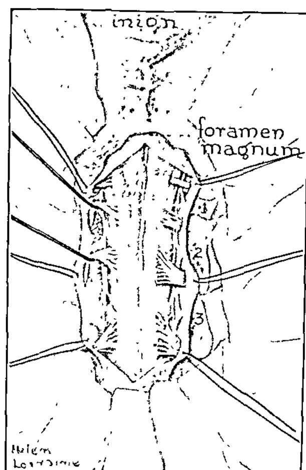



Fig 1233 —Section of three upper anterior cervical roots for spasmodic torticollis. The posterior roots on the left side are held aside with nerve hooks.

## Spasmodic Torticollis

Rarely there may be spasm of the sternocleidomastoid muscle on one side, producing torticollis. In such cases section of the spinal accessory nerve may be of great benefit. An incision is made along the anterior border of the sternomastoid muscle beginning just below the mastoid, and the muscle is retracted laterally. The nerve is identified as it appears beneath the digastricus muscle coursing toward the muscle. Care must be exerted to get all of the branches of the nerve by dissecting it upward as far as possible. The nerve is sectioned and the lower portion is sutured into the muscle to prevent regeneration.

In most cases of torticollis a more extensive procedure is needed. The upper three cervical motor roots (Fig. 1233) are sectioned along with both spinal accessory nerves. This operation is rarely indicated.

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# CHAPTER 85

# SPINAL CORD

Charles E. Troland

## ANATOMICAL AND PHYSIOLOGICAL CONSIDERATION

A knowledge of the normal curvatures of the spine is essential to proper treatment of spinal lesions. The spine has a marked anterior or lordotic curve in the cervical region and the vertebral bodies are relatively small and close together. The second through the sixth spines are usually bifid and the seventh spine is long. There is a posterior or kyphotic curve in the thoracic region where the bodies are considerably larger. The vertebral curve is again lordotic in the lumbar region and the vertebral bodies are very large. The vertebral bodies are separated from each other by the cartilaginous intervertebral discs, allowing mobility and giving a cushioning effect. The anterior and posterior longitudinal ligaments extend along the entire vertebral column, contributing much to its stability.

There is a considerable amount of loose adipose tissue just inside the spinal canal and in this tissue there are numerous thin-walled veins Beneath the epidural fat is the tough dura mater which sends a sheath along the emerging spinal nerves for a short distance. Closely attached to the dura is the thin arachnoid membrane beneath which the spinal fluid circulates. The pia mater is closely adherent to the spinal cord itself and contains many vessels.

The spinal cord begins at the foramen magnum and, because of developmental cephalic displacement, terminates at approximately the level of the upper border of the second lumbar vertebra. Each spinal segment sends out anterior and posterior roots which run in an increasing downward direction from the lower cervical region through the sacral segments. Thus, the cervical roots run almost horizontally to the intervertebral foramina, while the lower thoracic roots emerge from the canal approximately three vertebral levels below their origin from the cord. The lower portion of the spinal cord is shaped like a cone and is largely surrounded by lumbar and sacral roots which then form the cauda equina as they course downward to the lower intervertebral foramina.

The cord itself is an exceedingly complex structure and the location of many tracts is still imperfectly known For practical purposes, however, only a few facts are essential Pain fibers quickly cross in the cord and ascend in the anterolateral portion of the cord, whereas touch fibers ascend mainly in the dorsal columns to cross in the brain stem However, many touch fibers have other pathways and therefore a partial lesion rarely gives a sharp tactile level. Voluntary motor fibers have crossed at a high level and descend in the dorsal portion of the cord.

## INJURIES

The prime objective in operations in the vast majority of spinal cord injuries is the relief of pressure on the cord. Operation is not indicated in many cases, because frequently nothing will be gained by the procedure, a fact constituting a strong contraindication to operation. Fractures and fracture-dislocations may occur anywhere along the vertebral axis but are most common in the cervical and lumbar regions.

The indications for operation are few and definite: (1) in incomplete lesions that show evidence of increasing neurological deficit, (2) x-ray evidence of bony fragments projecting into the spinal canal, and (3) a positive Queckenstedt test indicating a block in cerebrospinal fluid circulation. In rare instances there may be fractures or dislocations of the posterior articulations where operation is indicated to avoid risk of damage by manipulation. Extreme care must also be taken in operating on such patients in order to minimize the possibility of further damage.

The simplest way to secure the desired objective—relief of cord compression—is the restoration of continuity of the vertebral column. Such restoration can usually be obtained by nonoperative measures. Even if the cord is apparently completely severed, it is advantageous to reduce the dislocation in order to minimize pain and give the stability needed for future ambulation.

### Cervical Injuries

Decompressive laminectomy is needed rarely in cervical injuries. The clinical picture is that of a paraplegia or a quadriplegia sometimes accompanied by a Horner's syndrome Skeletal traction is the treatment of choice in all such cases and should be applied even if decompression is needed. After shaving and preparing the skin, small drill openings are made in the parietal region. These openings are made with drills bearing guards to prevent penetration of the inner table of the skull, and care should be exercised to make the openings diagonally inward in the direction of the prongs of the tongs. The tongs (Fig. 1234) are inserted and tightened, and the prongs are surrounded by small collodion dressings Traction is then applied, beginning at 10 pounds and increased to 20 or 25 pounds (Fig. 1235) The patient can be turned easily and is usually comfortable.

### Thoracic Injuries

In the thoracic region it is more difficult to restore the normal contour of the vertebral column and, therefore, operation is indicated more frequently than in the cervical and lumbar regions. Hyperextension on a Bradford frame will reduce many dislocations and relieve cord pressure, and should be tried for at least twelve hours.

### Lumbar Injuries

The majority of fracture-dislocations in the lumbar region can be reduced by hyperextension, thus relieving pressure. It must be remembered that in most of the lumbar region the cauda equina is compressed rather than the cord and some regeneration in these roots is possible. Consequently operation is always indicated in this region if continued pressure is demonstrated or even suspected.

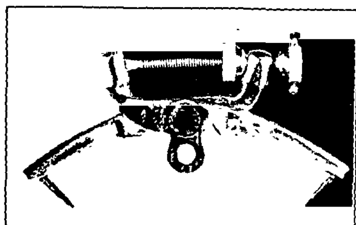


Fig. 1234—Crutchfield skull tongs. The greatest diameter of the conical points is greater than that of the drill point used for perforating the outer table of the skull.

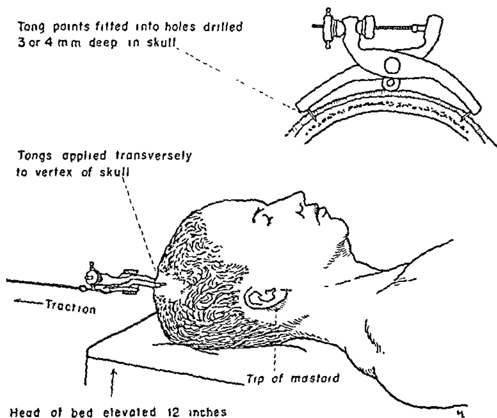



Fig. 1235—Tongs inserted in proper position and traction applied.

In spinal injuries of any type early treatment is essential. An attempt at restoration of the normal vertebral contour should be made at once, and if operation still seems indicated it should be performed within the first forty-eight hours or, preferably, earlier.

Penetrating wounds add the factor of potential infection, and therefore operation should be performed at once. Foreign bodies are removed along with bone spicules and the wound is thoroughly irrigated.

### Laminectomy

Operative procedures in spinal injuries should be performed with the greatest care as much of the supporting structures will have been damaged. Local anesthesia may be used, but intratracheal anesthesia is preferred. A straight incision is made over the site of injury and the adjacent two spines (Fig. 1236). The

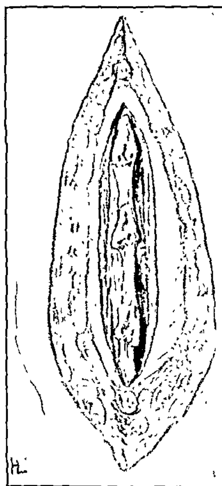


Fig. 1236 —Laminectomy. Exposure of spinous process.

muscles are gently separated from the spines and laminae and the bleeding points coagulated (Fig 1237). When the site of injury is well exposed, the spinous processes are removed and then the lamina either above or below this site is removed in order to approach the cord through relatively normal structures. Spicules of bone are moved along with blood clots and the dura is exposed (Fig. 1238). The dura is then carefully opened, again beginning either above or below the point of injury (Fig. 1239). The cord may be found contused and swollen, prohibiting any

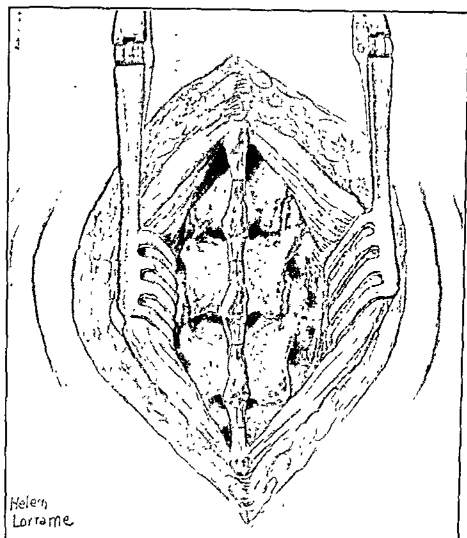



Fig 1237 —Laminectomy Exposure of laminae of three vertebrae. Dotted lines indicate location of section of interspinous ligament.

attempt at dura closure, and if such is the case the dura should be left wide open. On some occasions it is possible to reduce dislocations under direct vision by pressure and gentle manipulation. The muscles and skin are sutured in layers without drainage.

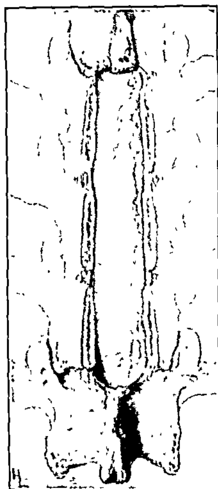


Fig. 1238.

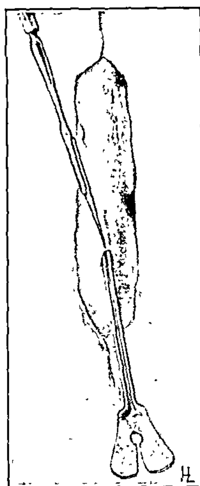


Fig. 1239.

Fig 1238.—Laminectomy. Exposure of dura.
Fig. 1239.—Laminectomy Incision of dura on grooved director.

## INFECTIONS

### Epidural Abscess

Spinal epidural abscesses are usually secondary to small furuncles over the back or elsewhere on the body but may also follow osteomyelitis of the vertebra. The clinical picture is that of pain, fever, leukocytosis, and rapidly progressive signs of cord compression Such patients constitute an immediate surgical emergency. If the precise location of the abscess cannot be demonstrated clinically, several cubic centimeters of Pantopaque can be put into the cisterna magna and the area of compression demonstrated by x-ray. A decompressive laminectomy is then performed and adequate drainage instituted. The dura should never be opened in such cases. In most instances the abscess points posteriorly, but sometimes the dura must be retracted in order to expose the principal infected area. If operation is performed early, prompt return of function can be expected.

### Arachnoiditis

Chronic adhesive arachnoiditis may constitute an indication for operation. This lesion may follow purulent or syphilitic meningitis and consist of a fibrotic band around the cord, compressing it and interfering with spinal fluid circulation The dense adhesions may be gently separated by sharp dissection. There may be prompt improvement in function but prognosis must be guarded as the adhesions tend to recur.

### Abscess of the Cord

Abscesses are rare in the spinal cord but may occur following meningitis or secondary to infection elsewhere in the body. The clinical picture is that of rapid loss of cord function simulating cord destruction. Laminectomy usually reveals the cord to be swollen and adherent to the dura. The subarachnoid space is protected by cotton pads and the purulent material is flushed away. Antibiotic therapy should be instituted at once and given intrathecally for several days.

### Tuberculosis of the Spine

The kyphos caused by collapse of a vertebral body may cause sudden or gradual onset of signs of cord compression which may disappear with hyperextension. If the symptoms continue, decompressive laminectomy is indicated Tuberculous granulations will have formed a spinal epidural granuloma which should be removed by blunt dissection and the dura left unopened.

### Penetrating Wounds

In penetrating wounds the added factor of potential infection makes early operation imperative, and it should be performed as soon as the patient's condition will permit. All foreign bodies, bone fragments, and nonviable tissue should be removed and the wound irrigated. If metallic fragments, however, have imbedded themselves in the bone or in other organs, they should be left alone as a search for such objects may cause some additional damage. When the patient is seen within the first twelve hours after injury, drainage is unnecessary but adequate chemotherapy should be administered. If the wound is obviously grossly contaminated, drainage may be needed, but the drain should not extend into the dura.

### The Care of Patients With Cord Lesions

Nursing care is of the utmost importance in the treatment of cord injuries. There may be not only paralysis and sensory loss but also loss of reflex control of circulation to the skin, increasing the danger of ulceration. Many of the patients lose a great deal of the subcutaneous fat, exposing all bony prominences such as the sacrum, trochanters, and heels to increased trauma. Unquestionably the best treatment for decubitus ulcers is prevention. The patient's position should be changed at least every two hours and the skin gently massaged. The bony prominences must be protected and by all means the skin must be kept dry.

If an abrasion of the skin does occur, it should be treated as a major wound. Dressings should be frequent and carried out with rigid asepsis. A bland ointment can be used to protect the surrounding tissue.

Maintenance of good nutrition is very important and a high protein diet is beneficial. Transfusions of whole blood may be necessary, particularly in cases that have required operation, and the fluid balance must be maintained.

The paralyzed bladder constitutes one of the most difficult problems, and set rules cannot be laid down for any particular case. A tidal drainage apparatus may be used in many cases, and some will develop an "automatic bladder." This is the establishment of a reflex mechanism that causes the bladder to empty automatically when distended. All patients who have developed an "automatic bladder" must be checked frequently for residual urine. Another method of treatment is suprapubic cystostomy, which permits easy bladder irrigation and carries little risk of infection. If the patient must be transported any great distance, the suprapubic cystostomy is always the method of choice.

All dislocations that have been reduced should be repeatedly checked by x-ray during the first six months after injury. Even if the reduction has been perfect and maintained for six weeks, there may later be some slipping, with possible neurological damage. In such cases fusion is indicated.

## CONGENITAL MALFORMATIONS OF THE VERTEBRAL CANAL

### Spina Bifida

Spina bifida is a congenital defect resulting from failure of the vertebral arches to close. There is frequently protrusion of the contents of the spinal canal through this defect, forming a meningocele (Fig. 1240), or, if the sac contains many neural elements, a myelomeningocele (Fig. 1241) The principal indications for operation in meningoceles are: (1) prevention of rupture of the sac with subsequent meningitis and (2) cosmetic purposes. The main contraindications are (1) the presence of marked hydrocephalus, (2) paralysis of the lower extremities, and (3) other gross congenital deformities.

It has been thought that the repair of a meningocele produces hydrocephalus and indeed many of the operated patients do develop hydrocephalus, but it is also true that many unoperated patients also develop this entity. It seems most probable that the failure of the cerebrospinal fluid to circulate and be absorbed in many such cases is due to another associated congenital deformity.

The time of operation is early in life, within the first few days or, at most, weeks of life. The skin and other tissue are very mobile at this stage and this makes closure much easier. Infection is also less likely to occur in the early cases.

Following preparation of the operative site, using mild antiseptic so as not to damage the skin, the incision is planned and scratched on the skin. When optional the incision should be transverse as tissue mobilization is easier in that direction (Fig. 1242). The skin is incised down to the sac and bleeding carefully controlled The neck of the sac is dissected free and the sac opened at one point (Fig. 1243). Nerve roots are freed if present and are replaced in the spinal canal If the sac has a small neck it can be obliterated with a purse-string suture, but, if larger, interrupted sutures may be used (Fig 1244) A flap of deep fascia is dissected out on each side of the defect (Fig. 1245), leaving the attachments to the margin of the defect (Fig 1246), and these flaps are overlapped to give good support over the spinal canal (Fig. 1247). The skin is then closed.



Fig 1240 —Baby, three months of age, with large sacral meningocele. No involvement of lower extremities, bladder or bowel. Excision of sac and closure of defect of spinal canal with fascial flaps were followed by complete recovery.



Fig. 1241 —Large inoperable lumbosacral myelomeningocele with ulceration in young infant.

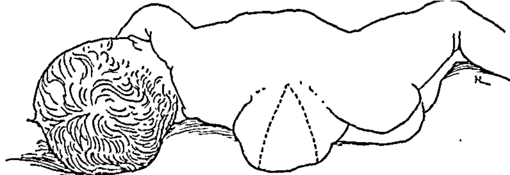


Fig. 1242.—Repair of spina bifida. Transverse elliptical skin incision for large sac.

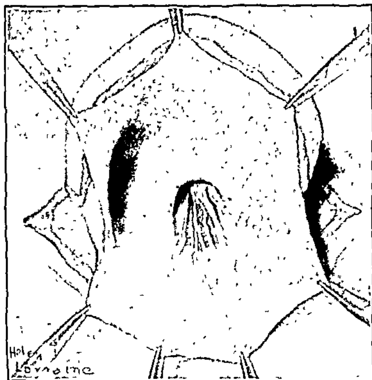


Fig. 1243.—Repair of spina bifida. The interior of the sac is exposed, showing small nerve filaments attached to the wall of sac. These filaments are dissected from the sac and returned to spinal canal.

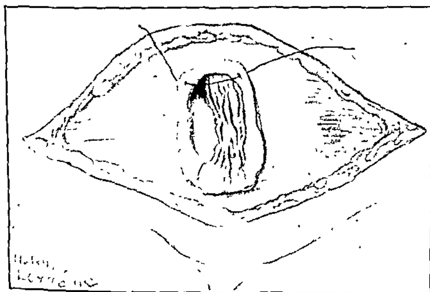


Fig. 1244.—Repair of spina bifida. The redundant sac has been amputated. Closure of the stump of the sac by interrupted silk sutures. The first suture has been placed.

Operative intervention in the intervertebral disc syndrome is not indicated until conservative treatment, i e., complete bed rest on fracture boards, heat, and a well-fitting lumbar support, has been tried except in cases showing progressive neurological deficit such as motor weakness or loss of sensation. Intravenous Tolserol can be administered to differentiate between severe muscle strain with spasm and nerve root pressure.

The patient is placed face down on the table which is broken to flex the lumbar region, and the incision is planned to expose the fourth and fifth lumbar interspaces. The muscles are separated from the spines and laminae and held with a retractor (Fig. 1249, *A*). The ligamentum flavum is incised and reflected

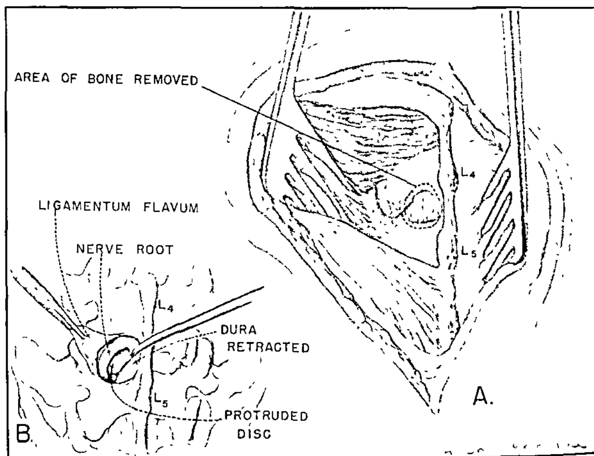



Fig 1249.—*A*, The muscles have been retracted from the spinous processes, revealing the intervertebral space. *B*, Ligamentum flavum has been retracted laterally, exposing the root being compressed by the protruding disc. It is rarely necessary to remove more than small pieces of the adjacent lamina to gain necessary exposure.

as a trap door to expose the underlying epidural fat and dura. The nerve root is retracted and the disc inspected. The pathological disc has a rubbery feeling and can be seen to compress the root (Fig. 1249, *B*). The protruding cartilage is removed and the space gently curetted. Routine removal of a lamina is to be condemned, but frequently a small amount of the adjacent laminae need be removed with a Kerrison punch in order to obtain adequate exposure. A pituitary rongeurs is a most useful instrument for removing the fragmental fibrocartilage from the interspace, and such fragments must be removed in order to minimize the possibility of a recurrence. One must always be careful not to rupture the anterior ligament and thus injure the aorta. Any hemorrhage that has occurred

from epidural vessels usually stops promptly with the use of Gelfoam. The ligamentum flavum is put back into place and the muscle and skin closed in layers with interrupted silk sutures.

The question of spinal fusion in conjunction with disc removal is still a controversial one, but it seems that it is seldom indicated. In cases with a long history indicating an unstable back, spondylolisthesis, or recurrent disc protrusions, a spinal fusion is definitely indicated, but a simple disc protrusion is not an indication for fusion.

Recently attention has been directed toward cervical disc protrusions. Here there is neck pain with radicular pain in the arm. In more massive protrusions there may be signs of cord compression. Operative treatment usually necessitates a hemilaminectomy in this region because of the overlapping of the vertebrae. Even more care must be used in operating in this region as the cord largely fills the canal and must be gently retracted. In bony protrusions it usually suffices to decompress the intervertebral foramen.

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# CHAPTER 86

# SURGERY OF PERIPHERAL NERVES

CHARLES E. TROLAND

## ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS

The principal peripheral nerves are mixed nerves and therefore consist of both motor or efferent and sensory or afferent components. The motor fibers leave the anteromedian aspect of the spinal cord to form the ventral root and join dorsal fibers coursing to the dorsal root ganglia, the sensory components, to form the *peripheral nerve. The nerve then passes to its proper domain to serve motor* and sensory function. The sympathetic nervous system elements are considered in a subsequent chapter.

The individual nerve fibers are made up of neurofibrils surrounded by a delicate membrane. Some fibers have a coating of myelin and are known as medullated fibers, whereas other fibers lack this covering. All of the fibers have an outer nucleated sheath known as the sheath of Schwann. The medullated and nonmedullated fibers are grouped into bundles or funiculi, which in turn are grouped into larger bundles, the whole nerve, by connective tissue, the epineurium. The connective tissue that penetrates between the nerve bundles is known as perineurium and that between nerve fibers as endoneurium.

Blood vessels are scattered throughout the connective tissue and have numerous anastomoses and collaterals along the course of the nerve. The importance of these vessels in the regeneration of injured nerves has been somewhat overlooked, but they are unquestionably important, and overstretching undoubtedly leads to rupture and secondary fibrosis.

When a nerve trunk is injured, degenerative changes take place in the distal nerve fibers, sheath cells, and the connective tissue coverings. Within a few days the fibrils show vacuoles, and within three weeks only a few granules remain. The myelin also becomes fragmented and separates into globules The neurolemma cells show productive changes and appear to remove some of the myelin and neurofibrillary remains. The epineurium becomes thicker and much denser, and fibrotic changes also extend throughout the nerve. There are also minor degenerative changes proximal to the site of injury, the extent of such changes depending largely upon whether there has been tearing of the nerve with hemorrhage and subsequent fibrosis.

Shortly after injury and suture of a nerve, some fine new branching neurofibrils appear in the central end, and soon thereafter regenerative changes appear at a slightly higher level These fibers form a fairly orderly mass of regenerating fibers

except for occasional end bulbs until the point of union is reached and here some fibers go out into surrounding scar tissue while others go across the scar and resume their orderly course in the distal segment.

## EXAMINATION IN NERVE INJURIES

It is manifestly impossible here to detail the course and relationships of all the peripheral nerves, but a thorough knowledge of regional anatomy and of the function of individual nerves is a prerequisite for diagnosis and surgical treatment. All too frequently, nerve lesions are overlooked in wounds because the operator is unaware that a major nerve courses throughout the injured area, and he fails to carry out simple tests indicating loss of function. The important effects of division or physiological paralysis of a nerve are motor paralysis and sensory loss, of which the former is usually the more important. With the loss of motor power there is inevitably some atrophy which becomes more pronounced with the passage of time, but such atrophy is frequently reversible. However, atrophy and subsequent fibrosis in the muscles do militate against a good functional result even if the nerve regenerates to the end plates, especially in the smaller muscles such as those in the hand supplied by the ulnar nerve.

The ability to perform a few simple movements in an injured extremity usually suffices to indicate that a major nerve has not been injured. Such testing is mandatory in instances of fractures where nerves may also have been injured, as the application of a cast may conceal loss of motor function. This is particularly important in the musculospiral nerve where the nerve may have sustained injury at the time of fracture, during manipulation, or later become imbedded in callus with loss of function.

## GENERAL PRINCIPLES OF NERVE REPAIR

The fundamental principles of peripheral nerve repair are that (1) the suture line should be as free from tension as possible and (2) there should be complete hemostasis. In incised wounds, which constitute the type most frequently seen in peacetime, tension is not often a problem, but when a considerable gap must be overcome it may be the main factor. Failure to overcome such tension will lead to a very high percentage of poor results. Extensive dissection and mobilization of the central and distal stumps often overcome the tension, and additional aid can sometimes be had by transplanting the nerve to a new bed, especially in the cases of ulnar nerve injuries Following adequate mobilization the joints of the affected extremity can be placed in optimum position to shorten the course of the nerve.

The importance of hemostasis cannot be overemphasized. Hematomas with the inevitable swelling and subsequent fibrosis militate strongly against regeneration. When the nerve ends have been cut back to good tissue, there is frequently brisk bleeding which can be controlled by temporary application of strips of Gelfoam.

It is important to avoid twisting of the trunks so that the funiculi of the central stump will approximate the proper funiculi of the distal trunk. This proper approximation can be facilitated by placing a sling suture of fine tantalum wire or silk through the two stumps and pulling them into contact. This suture also prevents the nerve bundles from retracting up the sheaths,

The material needed for suturing nerves must be small in caliber, have good tensile strength, and be relatively inert so as not to stimulate growth of fibrous tissue and thus adversely affect nerve regeneration. Fine tantalum wire has been advocated for this purpose and it certainly has some advantage. It is very doubtful, however, if the use of tantalum produces any better results than fine silk.

The proper time for nerve exploration and suture has received extensive study. As far as exploration is concerned in instances where the condition of the nerve is not known, there can be no question but that early exploration is indicated. Tinel's sign, which is elicited by gently tapping over the course of the nerve with production of tingling over the distribution of the nerve, is not reliable in determining whether or not the nerve has been severed. There is no test that accurately determines whether a nerve has been anatomically or physiologically interrupted. Therefore, the nerve should be explored early, as otherwise valuable time will be lost and unnecessary atrophy occur. When the nerve has been exposed and is found in continuity with relatively little fibrosis, it should be returned to its bed and the patient carefully followed for any evidence of returning function for approximately a month. The dictum is to explore radically but be conservative in the management of the exposed nerve. Old nerve injuries should also be explored, as surprisingly good results, especially as regards sensory return, have been obtained in some cases.

In incised wounds with nerve injury the nerve should be sutured as soon as possible for there is no valid reason for delay in such cases. In such wounds the nerve trunks are readily mobilized and can be brought together without tension. In extensive wounds that need débridement it is usually not feasible to perform primary nerve suture and indeed it may be difficult in such cases to determine the total extent of the injury. Nerve suture in such instances should not be looked upon as an emergency procedure but should be carried out as soon as optimum conditions prevail. Early secondary nerve sutures give excellent results. Nerves should not be sutured in infected wounds as the suture material simply acts as a foreign body and the increased fibrosis hinders nerve regeneration.

## Nerve Suture Technic

The first step of importance in nerve suture is the insurance of adequate exposure. The incision should begin and end well above and below the injured area. Elective incisions should never be made perpendicularly across a flexor joint crease, as resulting scar tissue may produce contractures. After adequate exposure the injured nerve ends are dissected free, preferably by sharp dissection. Gentleness in handling the nerve is essential and for this reason moist cotton pledgets are preferable to gauze for sponging. In incised wounds promptly sutured the actual nerve suture may now be performed, but usually the neuroma on each stump must be resected (Fig. 1250). This is done by holding the neuroma on a cotton strip supported by the finger and sectioning it with a sharp blade at right angle to the nerve trunk, beginning near the end of the neuroma. Repeated sections are made until healthy neuraxes are disclosed and the cut ends are smooth. There is usually some bleeding at this point which is controlled by placing a strip of Gelfoam over the end and leaving it for a few moments.

When the neuroma has been removed from each end, a central suture of tantalum or fine silk is passed through the entire trunks about 1.0 to 1.5 cm. from

the ends and tied snugly but not tightly (Fig. 1251, *A*). This suture holds the ends together for subsequent suturing and prevents retraction of the nerve funiculi up the sheath. The sheath of the divided nerve is then reapproximated with fine silk or tantalum sutures that penetrate only through the sheath (Fig. 1251, *B*). After the epineural sutures are placed on one side, the nerve is rotated by clamps on these sutures, and the undersurface of the nerve is exposed and sutured (Fig. 1251, *C*).

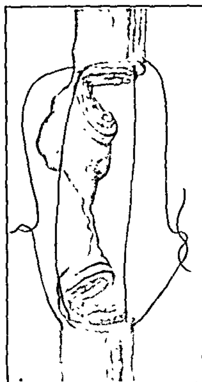


Fig. 1250.—When the nerve is badly damaged, the injured portion is first partially resected, then stay sutures are placed as shown in the illustration, and the resection of the damaged area is completed. In this way accurate approximation of the funiculi is obtained.

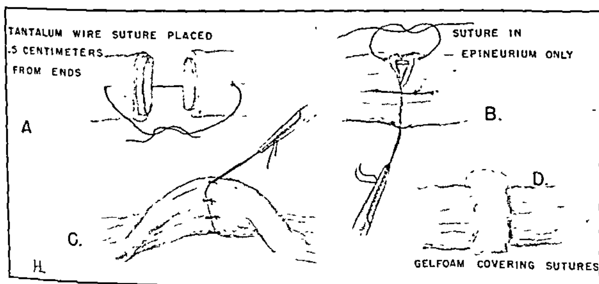



Fig. 1251.—*A*, A sling suture of tantalum or silk is placed through the nerve ends. This suture is not needed in most incised wounds where there is no tension *B*, Sutures are placed through the epineurium only The needle as well as the suture should be of fine caliber. *C*, Nerve is rotated for placing of posterior sutures. *D*, A small strip of Gelfoam covers the suture line.

The number of sutures needed to approximate the sheath and prevent projection of fibers varies, but the goal of precise approximation must be attained. Many substances have been used to protect the suture line from invasion of scar tissue from surrounding tissue, although such invasion is minimal if good sheath approximation has been attained and hemostasis is complete. A small cuff of Gelfoam just over the suture line (Fig. 1251, *D*) will protect this region and seems preferable to tantalum foil, fascia, or other substances. The nerve is returned to its bed and careful layer approximation of the wound is performed.

### Bulb Suture

In some cases where there has been extensive loss of nerve tissue it is obviously impossible to attain end-to-end suture of healthy fibers. Here the two ends of the nerve are mobilized as much as possible and the fibrosed ends are overlapped and sutured with the injured limb in optimum position for relaxation. The extremity is then slowly extended over a period of several weeks to stretch the nerve. The wound is then reexplored, the neuromas are resected back to healthy tissue, and routine suture is performed. This stretching may well produce intraneural hemorrhages with scar formation and, therefore, must be regarded as a desperation procedure. However, it is better to use this procedure than to leave a gap between the nerve ends or to use present methods of nerve grafting.

### Neurolysis

The exposure nerve may be found to be intact but bound down by dense scar tissue. It may be dissected free and placed in a new bed (Fig. 1252), if possible in an intermuscular septum where scarring will be minimal. If the sheath seems to be extremely thick, it may be split longitudinally in order to free the individual nerve fibers (Fig. 1253).

### Nerve Graft

If the gap between the ends of the nerve cannot be overcome by any method, a graft may be indicated Heterografts are of no value and homografts are almost equally useless except for small nerves such as the facial Autografts may be useful in some cases, and undoubtedly further work will increase their range of usefulness Small cable grafts may be taken from the sural, intercostal, or anterior cutaneous nerves to bridge the gap between the nerve ends (Figs. 1254, 1255, and 1256). Thick homografts can be used in the rare instances where there is also an amputation, providing a source for a graft of appropriate size.

### Postoperative Care

The optimum position of the limb for producing relaxation of the nerve must be maintained during operation and for approximately two weeks thereafter. The limb can then gradually be brought out to full extension or flexion. It is important that full mobility of the joint be arrived at gradually, but it is equally important that the mobilization begin in two weeks Otherwise periarticular adhesions and fibrosis may postpone full functional recovery and even necessitate orthopedic manipulation

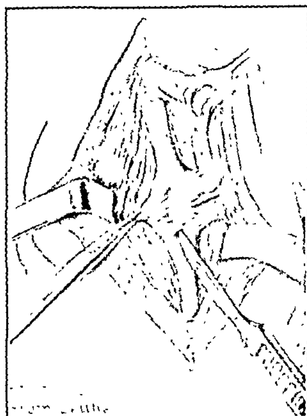


Fig 1252.—Neurolysis. The scar around the nerve is removed until the epineurium is exposed The nerve is transferred to a new bed, preferably in an intermuscular septum if possible *in order to avoid bleeding (From Lewis: System of Surgery )*

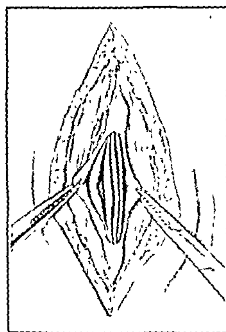


Fig 1253 —When the scar is thin, the outer sheath is incised and the funiculi are freed This operation is called hersage, or endoneural neurolysis (Redrawn from Lewis: System of Surgery )

The paralyzed muscles should be splinted in a relaxed position while awaiting nerve regeneration, but the splint should interfere with other functioning muscle groups as little as possible.

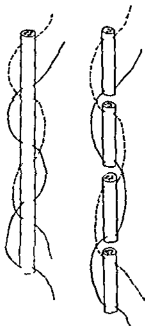


Fig. 1254.

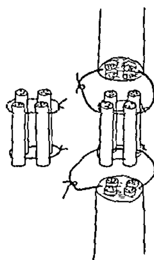


Fig 1255.

Fig. 1254.—Elsberg's method of cutting sections of a small nerve for cable transplantation.

*Fig. 1255.—Cable is being sutured into the defect between the ends of the nerve.*

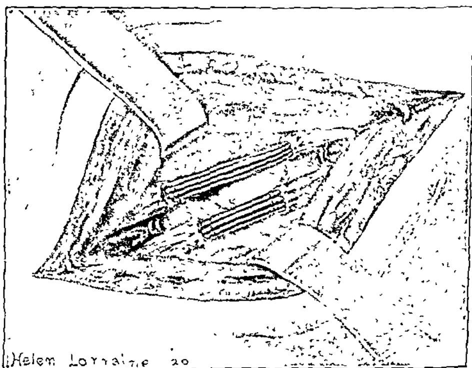



Fig 1256.—Appearance of nerve after cable graft has been completed, according to Elsberg

Physiotherapy, emphasizing massage and passive motion, should be started as soon as possible Such treatment will avoid joint contractures and will aid in maintaining some tone in the paralyzed muscles Voluntary movement should be encouraged in all possible ways as soon as it can be accomplished.

## TREATMENT OF SPECIFIC NERVE LESIONS

### Brachial Plexus

This intricate plexus is formed by the anterior divisions of the fifth, sixth, seventh, and eighth cervical nerves along with branches from the fourth cervical and first thoracic. It extends from the neck to the axilla and consists first of trunks and then of three cords: lateral, median, and posterior. The lateral cord gives rise to the musculocutaneous nerve and the outer portion of the median, while the median cord divides into the inner portion of the median, the ulnar, and the medial cutaneous nerves. The posterior cord becomes the radial and axillary nerves.

Brachial plexus injuries are difficult problems and their treatment is attended by a high percentage of poor results Many of these injuries are of an avulsion type caused by traction on the arm and cannot be treated surgically, although there may be spontaneous recovery if the injury has not been too severe. Incised wounds may show good regeneration if properly treated; however, there is frequently a complicating vascular injury. Extensive wounds of the plexus that require resection of much of the nerve bundles are almost impossible to treat because of the difficulty in securing relaxation, but some tension can be relieved by elevating the shoulder and folding the arm across the chest.

The entire plexus can be exposed by an incision beginning at the base of the neck and extending parallel to and just above the clavicle, curving along the anterior deltoid crease and ending in the upper third of the biceps groove (Fig. 1257). The upper portion of the plexus lies behind the scalenus anticus muscle, which is sectioned. Exposure of the mid portion is obtained by sectioning the clavicle which is wired after the completion of treatment of the nerves and may be shortened slightly to provide additional relaxation The exposure is completed by sectioning the tendon of the pectoralis major muscle.

### Musculocutaneous Nerve

This nerve arises from the lateral cord of the brachial plexus and supplies the coracobrachialis, brachialis, and biceps muscles, which are the primary flexors of the forearm. It ends as a sensory nerve serving a large portion of the flexor and lateral surfaces of the forearm Motor impairment following section of this nerve may not be severe, as the brachioradialis muscle, supplied by the radial nerve, can accomplish excellent forearm flexion

### Median Nerve

The median nerve is formed from the medial and lateral cords of the brachial plexus and thus contains fibers from the sixth, seventh, and eighth cervical and first thoracic nerves. It supplies all of the superficial muscles on the flexor surface of the forearm except the flexor carpi ulnaris and also all of the deep muscles except a portion of the flexor digitorum profundus In the hand it gives motor power for most of the thumb movements and also supplies the greater part of the sensation to the hand. Thus a lesion of the median nerve at any point carries a severe penalty, as even near its termination it has important sensory and motor components.

Exposure of the median nerve shortly after its origin in the plexus can be obtained by an incision curving along the anterior deltoid crease down to and along the biceps groove (Fig. 1257). Middle arm lesions are easily exposed by a straight incision along the biceps groove. A double flap incision (Fig. 1258) gives exposure at the elbow where the nerve passes between the two heads of the pronator teres, and some relaxation can be obtained by sectioning one of these bundles.

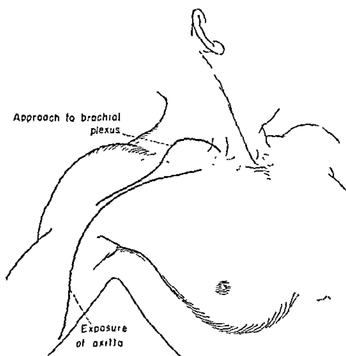



Fig. 1257.—Brachial plexus is exposed by incision beginning over sternomastoid muscle and extending across clavicle to anterior deltoid crease. Axilla and upper arm nerves are exposed by incision beginning at clavicle, extending along anterior deltoid crease and thence down bicipital groove. Pectoral muscles are reflected at their insertion

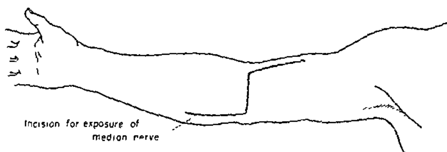



Fig 1258.—Median nerve is exposed at the elbow by a double flap incision with middle segment transverse to avoid flexion contracture

At this point the important motor fibers to the flexor muscles originate and, therefore, the nerve must be handled with particular care if injury to these branches is to be prevented. Below the elbow the nerve runs a straight course and relaxation can be obtained only by wrist flexion. In incised wounds at the wrist it is essential that wide exposure be obtained so that the nerve ends can be properly identified, as all too often the nerve injuries here are overlooked or the nerve is sutured to the palmaris longus tendon The small nerve fibers in the hand should be diligently sought for and sutured, as loss of sensation in that region can be disabling.

Causalgia is commonly associated with median nerve lesions, particularly when such lesions are partial. This burning, frequently agonizing pain is usually accom-

panied by evidence of sympathetic irritation and in early cases responds well to sympathetic pathways interruption.

One easy test for median nerve function is to place the hands together as in supplication where it will be noted that the index finger of the affected side cannot be brought down on the dorsum of the normal hand.

## Ulnar Nerve

The ulnar nerve arises from the medial cord of the brachial plexus and courses through the arm medial to the brachial artery. In the lower arm it passes posteriorly to go behind the internal epicondyle and then enters the forearm between the heads of the flexor carpi ulnaris. In the arm it supplies the flexor carpi ulnaris and the ulnar portion of the flexor digitorum profundus while in the hand it innervates the interossei, the ulnar lumbricales, the adductor transversus and obliquus pollicis, a portion of the flexor pollicis brevis, and the muscles of the hypothenar eminence.

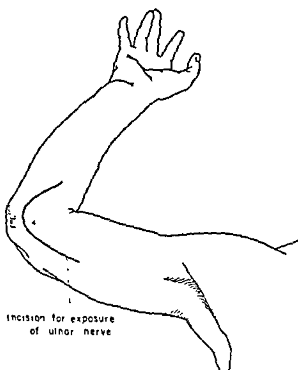



Fig. 1259.—Incision to expose ulnar nerve at the elbow follows the course of the nerve.

Section of the ulnar nerve produces the deformity known as clawhand. The lumbricales normally flex the first phalanx and extend the distal two phalanges, and paralysis of these muscles permits antagonistic muscles to produce extension of the first phalanx and partial flexion of the other phalanges. There is loss of sensation on the ulnar side of the palm, the little finger, and the ulnar side of the ring finger

The course of this nerve is very favorable for securing relaxation, as transposition to the flexor surface of the elbow produces a much more direct route (Fig. 1259). In such transpositions the fibers to the flexor carpi ulnaris may have to be sacrificed, but such sacrifice is always warranted in order to gain function in the hand.

sciatic nerve passes down the thigh under cover of the biceps. It is frequently injured in warfare and can usually be sutured easily if there is no great loss of nerve substance. A question-mark incision (Fig. 1260, *B*) followed by reflection of the gluteal muscles exposes a high lesion, and a continuation of the incision exposes the entire nerve in the thigh.

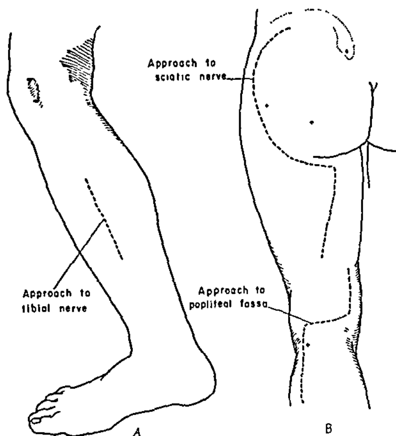



Fig. 1260.—*A*, Incision for exposure of tibial nerve in mid portion of leg. *B*, Question-mark incision for exposure of sciatic nerve with extension of incision down thigh. Popliteal fossa is exposed by double flap incision going horizontally across to avoid flexion contracture.

## Tibial Nerve

The tibial nerve is the largest terminal branch of the sciatic nerve and extends throughout the popliteal fossa behind the popliteal vein. It then supplies the muscles of the calf, which are the plantar flexors of the foot, and continues down to the muscles of the sole of the foot. The sensory component supplies the sole of the foot. The tibial and peroneal nerves are exposed at their origin in the popliteal fossa by a double-flap incision (Fig 1260, *B*) similar to that used at the elbow for the median nerve Injury in the mid portion of the leg is repaired through an incision along the inner side of the calf of the leg (Fig. 1260, *A*).

## Common Peroneal Nerve

The common peroneal nerve divides into deep and superficial branches. The deep branch passes laterally and externally around the head of the fibula and may be injured in fibular fractures It innervates the dorsiflexors of the foot, and a paralysis, therefore, produces foot drop with a steppage gait. The superficial branch becomes subcutaneous in the lower third of the leg and supplies sensation

to the dorsum of the foot and lateral aspect of the leg. Injuries to this nerve are rather frequent and may be difficult to treat when they occur just below the knee, as the main motor branches are given off here.

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# CHAPTER 87

# SURGERY OF THE SYMPATHETIC NERVOUS SYSTEM

CHARLES E. TROLAND

## INTRODUCTION

Operative procedures have been performed on the sympathetic nervous system for over half a century, but within the last several decades these procedures have been greatly popularized and their scope increased. As is usual with new operations, many of these procedures have been carried out too frequently and some published results have been more indicative of the surgeons' enthusiasm and hopes than of actual operative benefits. However, most of the operative attacks on the sympathetic system do rest on sound anatomical and physiological bases and increasing knowledge and clinical application are broadening the field for operative attacks while placing in true perspective the results that can be attained.

## ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS

The sympathetic trunks consist of ganglionated chains that run on either side of the vertebral bodies from the base of the cranium to the coccyx. The ganglia are segmentally arranged except in the cervical region, but there are numerous deviations from a strictly segmental arrangement, particularly in the lumbar region. The interganglionic portions of the trunks consist mainly of longitudinally directed nerve fibers. Every spinal nerve is connected with the sympathetic trunk on the same side by communicating rami.

A condensation of ganglia has occurred in the cervical region with three or four ganglia connected with the eight cervical nerves. The superior cervical ganglion is a large fusiform structure located at the base of the skull between the internal carotid artery and the jugular vein Preganglionic fibers reach it through the sympathetic trunk from the upper thoracic nerves and sympathetic roots leave it to join the upper cervical nerves. There are numerous connections with the hypoglossal, vagus, and glossopharyngeal nerves, and the major portion of the internal carotid plexus is also derived from this nerve. In fact the rostral rami of the superior ganglion constitute the principal cephalic extension of the sympathetic nerves.

A thin strand on the deep fascia of the neck connects the superior cervical ganglion with the inconstant middle ganglion which usually lies at the level of the sixth cervical vertebra. Sympathetic roots leave this ganglion to join the fifth and sixth and sometimes other adjacent cervical nerves. The intermediate cervical ganglion is located medial to the vertebral artery at the level of the eighth cervical nerve and sends sympathetic roots to the sixth cervical nerve. From this ganglion

a large ramus passes ventral to the vertebral artery to the inferior cervical ganglion, and there are also interganglionic connections by way of the ansa subclavii. The first thoracic ganglion is usually fused with the inferior cervical to form the stellate ganglion from which important fibers join the cardiac plexus as well as the common carotid, vertebral, and subclavian arteries.

The sympathetic trunk then extends into the thorax and lies ventral to the necks of the ribs Communicating rami connect all of the thoracic ganglia with corresponding spinal nerves. Rami from the sympathetic trunk in the fifth to tenth segments unite to form the greater splanchnic nerve which passes through the diaphragm to the celiac ganglion. Other rami from the ninth and tenth thoracic segments form the lesser splanchnic nerve which terminates mainly in the aorticorenal plexus, while the least splanchnic arises from rami of the eleventh and twelfth ganglia and goes to the renal plexus.

A thin strand of fibers extends from the thorax into the abdomen between the medial and lateral crura of the diaphragm. The trunk curves ventrally to the ventrolateral surface of the second lumbar vertebra and then lies adjacent to the bodies of the vertebrae along the medial border of the psoas muscle. There is great variability of the chain in this region with frequent fusion of adjacent ganglia. Fibers are sent to all of the spinal nerves and also to autonomic plexuses on the major abdominal vessels.

The preganglionic vasomotor neurones to the upper extremities arise from the second to the eighth dorsal segments and the vasomotor neurones to the lower extremity from the ninth thoracic to the second lumbar segments.

A large number of the fibers in the splanchnic nerves convey afferent impulses from viscera and some of these impulses are of pain. Sensory denervation of a viscus can be obtained by interrupting the nerves accompanying the vessels if the viscus or organ has a pedicle.

Probably the principal function of the sympathetic system is the regulation of vascular tone by vasoconstriction. It has been thought that removal of the ganglia rendered the vessels extremely sensitive to circulating adrenalin, but this concept has been found to be of more importance in experimental animals than in man It is much more important to secure complete sympathetic denervation by all available means than to attempt preganglionic denervation, as poor results are more likely to be due to inadequate nerve removal than to hypersensitivity to any circulating substance.

## SUPERIOR CERVICAL GANGLIONECTOMY

### Indications

Although many enthusiastic reports have appeared regarding the benefits of superior cervical ganglionectomy in a variety of conditions, it remains a procedure of dubious merit. It may be of value in some cerebral vasospastic conditions, although this has not been definitely proved, and is almost surely without therapeutic benefit in any type of face or head pain, migraine, or many other conditions for which it has been recommended. There does appear to be definite curative advantage in removing this ganglion in cases of trophic corneal changes which sometimes occur following rhizotomy of the sensory root of the fifth cranial nerve.

## Operative Procedure

The neck is extended over a small sandbag and the head is rotated away from the side of operation. Local or general anesthesia may be used, with ether probably preferable. An 8 cm. incision (Fig. 1261) is made over the upper portion of the posterior edge of the sternocleidomastoid muscle, and the platysma fibers are sectioned. The spinal accessory nerve should be identified and protected, and it is well to avoid




Fig. 1261.—The head is extended and rotated away from the operative side. Incision is made at posterior border of sternocleidomastoid muscle.

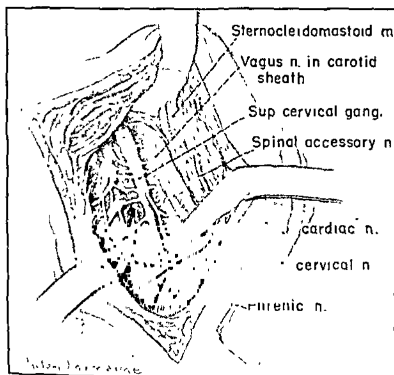



Fig 1262.—The carotid sheath is retracted forward, exposing the large superior ganglion with its numerous connections

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## SUPERIOR CERVICAL GANGLIONECTOMY

### Indications

Although many enthusiastic reports have appeared regarding the benefits of superior cervical ganglionectomy in a variety of conditions, it remains a procedure of dubious merit. It may be of value in some cerebral vasospastic conditions, although this has not been definitely proved, and is almost surely without therapeutic benefit in any type of face or head pain, migraine, or many other conditions for which it has been recommended. There does appear to be definite curative advantage in removing this ganglion in cases of trophic [illegible] which sometimes occur following rhizotomy of the sensory root of [illegible] nerve.

## Operative Procedure

**Anterior Approach for Cervicothoracic Ganglionectomy.**—This approach can be used for hyperhidrosis but does produce a Horner's syndrome which is somewhat disfiguring unless bilateral. In thin-necked individuals it can be of great aid in stopping the pain of angina pectoris. The anterior approach is probably not the most suitable for vascular disorders of the arm as it does not permit resection of the anterior roots of the second and third thoracic ganglia.

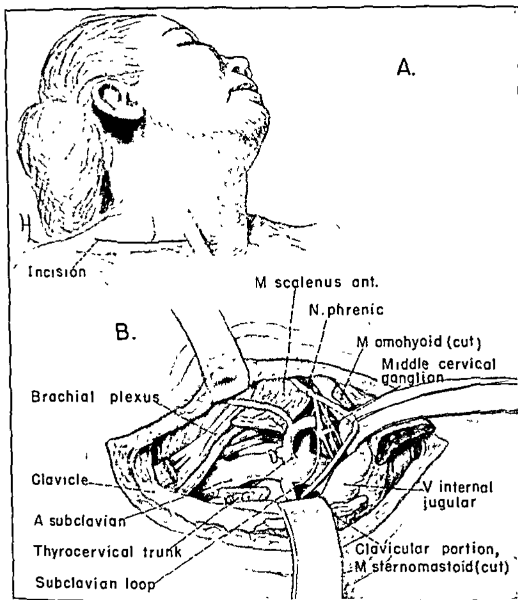



Fig. 1263.—*A*, Skin incision is just above the clavicle, extending lateralward from mid portion of sternocleidomastoid muscle. *B*, The scalenus anticus muscle has been sectioned to expose the subclavian artery and its branches

The patient is placed on the table in position for a thyroidectomy with the head rotated slightly away from the side of operation General anesthesia with an intratracheal tube is necessary because of the danger of opening the pleura. An incision about 7 cm. in length is made parallel to and about 2 cm above the clavicle, beginning at the insertion of the sternocleidomastoid muscle (Fig. 1263, *A*) The platysma is sectioned and the external jugular vein cut between ligatures. Exposure is facili-

cutting many of the superficial fibers of the upper cervical nerves. The carotid sheath is dissected free and retracted medially along with the vagus nerve. The large, fusiform superior ganglion is then seen on the prevertebral muscles with numerous connections to neighboring nerves (Fig. 1262). The large superior cardiac nerve can also be seen as it leaves the ganglion. The sympathetic trunk is picked up on a hook and sectioned below the ganglion. Working upward, the rami are sectioned and the ganglion is removed. The wound is closed in layers.

## THORACIC SYMPATHECTOMY

### Indications

Thoracic sympathectomy may be of utmost value in vascular disorders of the upper extremity. This is particularly true in Raynaud's disease where vascular spasm is the most important factor and can be relieved by sympathectomy. Operative intervention should be carried out early in order to prevent, or at least delay, anatomical changes. In Buerger's disease or arteriosclerosis where occlusive changes have already occurred, good results may still be obtained by abolishing vasoconstriction that occurs as a result of the irritative or occlusive vessel damage.

Sudeck's atrophy may be benefited in some cases by abolition of sympathetic impulses, but prognosis here must be very guarded. In late cases the operation is rarely of benefit. Excessive sweating of the hands, which can be an extremely annoying disorder, can be easily and permanently stopped by upper thoracic ganglionectomy.

Causalgia, a severe, burning type of pain usually associated with nerve injuries and frequently accompanied by vasomotor changes can often be cured by sympathectomy. Preliminary block of the sympathetic chain should be carried out as a diagnostic test and, if successful, ganglionectomy is indicated In early cases a high percentage of excellent results can be obtained. Amputation stump neuralgia may also be abolished if treated early, but late sympathectomy in these cases is of no value.

Angina pectoris, when severe, may constitute an indication for thoracic sympathectomy. These cases have frequently had temporary interruption of sympathetic fibers by alcohol injection of the ganglia, but this procedure is now done with increasing rarity as it is an extensive procedure in itself, is temporary, and is often accompanied by a chemical neuritis as severe as the original pain. The objection that sympathectomy deprives the patient of a warning of impending cardiac insufficiency is not valid, as a sense of fullness of the chest will still be present. The operation for angina is naturally very serious because of the patient's cardiac status, but a surprisingly large number of incapacitated people can be returned to useful lives by this procedure

The shoulder-hand syndrome, consisting of severe, incapacitating pain in the shoulder and hand, and caused by a variety of disorders such as angina, bursitis, arthritis, and many other conditions, will frequently yield to adequate sympathectomy In early stages anesthetic blocks may be effective, but in later stages operation is indicated Ganglionectomy should not be too long delayed as long immobilization caused by the pain may produce severe joint and muscle changes.

of the second and third ganglia will effectively abolish sweating in the upper extremity. In vascular disease a thorough denervation is essential and, therefore, the second through the sixth thoracic ganglia are removed as well as the anterior and posterior roots of the second and third intercostal nerves. Many vasomotor fibers pass over the anterior roots of these nerves and intradural section makes the dura an additional barrier to regeneration. Other vasomotor fibers undoubtedly travel over

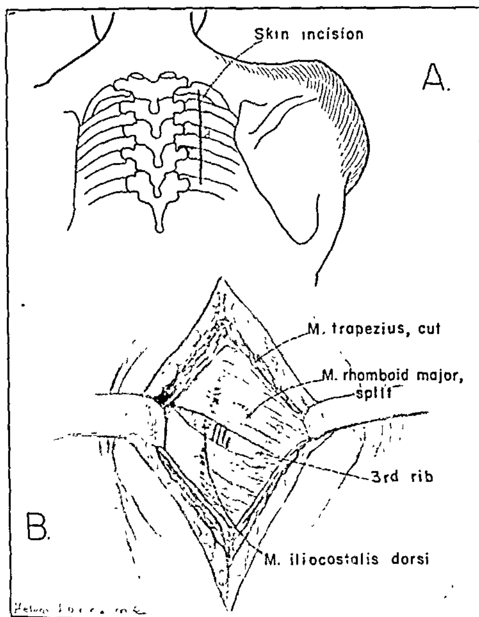



Fig. 1265—*A*, Skin incision is placed 5 cm lateral [illegible] third and fourth ribs. *B*, Trapezius has been sectioned [illegible] fibers. When third and fourth ribs are being resected, it [illegible] exposure.

the first thoracic nerve, which cannot be sectioned without serious motor disability in the hand. In some procedures the ganglionated chain is sectioned below the third ganglion, the second and third ganglion then being decentralized and wrapped in silken cuffs to prevent regeneration and to produce a preganglionic sympathectomy. As the factors of regeneration and incomplete sympathectomy seem more important than any sensitization to circulating adrenalin and sympathin, it is preferable

tated by sectioning the clavicular head of the sternocleidomastoid muscle, and the anterior scalene muscle is visualized by blunt dissection of the cervical fat. The phrenic nerve is identified running from the outside inward in the scalene fascia and is retracted medially along with the internal jugular vein. The anterior scalene muscle is sectioned just above its insertion into the first rib and allowed to retract, exposing the brachial plexus and subclavian artery. (Fig. 1263). The thyroid axis is exposed and usually has to be divided, permitting development of the common carotid artery which arises from the subclavian on the right and independently from the aorta on the left. The vertebral artery is then seen as a posterior branch of the subclavian and the stellate is visualized just medial to the vertebral artery and lying against the seventh cervical and first thoracic vertebral bodies. Care must be taken on the left side not to damage the thoracic duct.

Sibson's fascia, which attaches the apex of the pleura to the posterior portion of the first rib, is cut and the pleura is bluntly retracted medially and downward (Fig. 1264). The stellate ganglion can be picked up on a hook and its rami sectioned before it is grasped with a hemostat. The rami of the upper thoracic ganglia are then divided, great care being exercised not to start bleeding. Good lighting is essential and usually metal nerve clips are better than the cautery to prevent bleeding from intercostal vessels. The upper four thoracic ganglia can be resected by this approach.

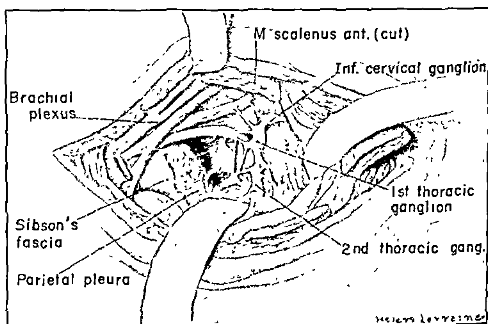



Fig. 1264.—Sibson's fascia has been cut and the pleura retracted downward along with subclavian vessels. Sympathetic ganglia and trunk are exposed on the prevertebral fascia

If the pleura has been opened, a catheter should be inserted and the pleural cavity aspirated at the conclusion of the operation. The clavicular head of the sternocleidomastoid muscle is sutured when the wound is closed.

Posterior Approach for Cervicothoracic Sympathectomy.—This is usually the preferable approach for upper thoracic sympathectomy and the inferior cervical ganglion can also be reached. If the operation is performed for the pain of angina pectoris, it is necessary to remove the upper four thoracic ganglia, whereas removal

tor spinae muscle is retracted medially and the third and fourth ribs are identified. It is extremely important to identify accurately the ribs, as, if the second rib is mistaken for the third, the first and second thoracic nerves will be resected in the course of complete denervation rather than the second and third nerves with resultant hand weakness. The ribs can only be identified positively after the overlying muscles have been sectioned or retracted and the finger is passed upward on the rib cage to feel the ribs. The first rib follows a different course in that it plunges downward and forward and can thus be identified. Preliminary marking by x-ray is of little value.

The third and fourth ribs are freed of the intercostal muscles and pleura and approximately 6 cm. are removed. The pleura is gently separated with the fingers and gauze and the central end of the rib with the transverse process rongeured away as far centrally as possible. The pleura is then widely separated from the thoracic wall, exposing the sympathetic chain (Fig. 1266, *B*), which is lifted on a hook below and grasped with a clamp. Usually the seventh thoracic ganglia can be mobilized and the rami cut and then the chain is sectioned at that level. The rami of each ganglion are sectioned and the chain freed until the stellate ganglion is identified as being large, dumbbell-shaped, and possessing many rami. The chain is removed just above this structure.

The second intercostal nerve is cut at the lateral edge of the exposure and gentle traction is applied while the nerve is dissected free at the intervertebral foramen. The posterior root ganglion is brought into view and the root is sectioned central to this structure. Slight additional traction brings out a good segment of the anterior root, which is then divided (Fig. 1266, *A*). A similar procedure is performed on the third root.

If the pleura has been opened, a catheter is inserted and the cavity is aspirated after routine closure of the muscles and skin. It is wise to aspirate extrapleurally even if the pleura has not been opened, as such aspiration diminishes postoperative bleeding and pain.

The intercostal nerves do not need to be resected if the operation is being performed for hyperhidrosis or the pain of angina pectoris. For hyperhidrosis only the second and third ganglia need to be removed and this can be accomplished after removal of only one rib.

## THORACOLUMBAR SYMPATHECTOMY

### Indications

The principal indication for extensive thoracolumbar sympathectomy is the treatment of essential hypertension. Patients under fifty years of age with labile blood pressures who do not evidence marked cardiac, renal, or cerebral damage but do show advancing hypertension with symptoms are candidates for this operation. Proper selection of the patients is of utmost importance. A great deal of controversy still rages regarding the merits of this operation but there can be little doubt that properly chosen patients can have their pressure reduced and be rendered asymptomatic by this operation

Visceral pain can often be abolished by splanchnicectomy and lower thoracic sympathectomy. Pancreatic and liver pain in particular can be markedly relieved

to remove the ganglia over a considerable section—stellate to sixth thoracic—and thus abolish as many sympathetic fibers as possible.

Intratracheal anesthesia is used because of the possibility of opening the pleura The patient is placed prone on the table with pillows under the chest to allow the shoulders to slope forward and outward. An alternate position is that of having the patient on the side with the operative side up and the shoulder pulled forward to displace the scapula. *The prone position is naturally preferable when both sides*

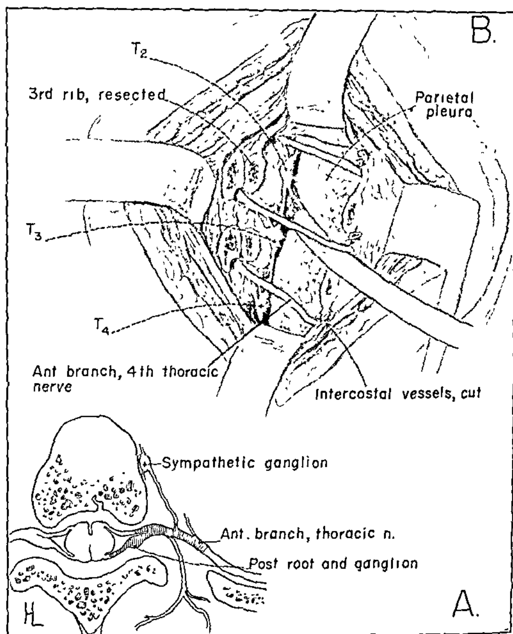



Fig 1266 —Ribs have been resected and pleura retracted, exposing intercostal nerves and sympathetic chain *A* shows central extent of intercostal nerve section.

are to be denervated at the same operation An incision is made about 10 cm in *length, parallel to the vertebral column and approximately 5 cm. from the midline* (Fig 1265, *A*). It is centered over the third and fourth ribs. The trapezius, rhomboid and serratus posterior muscles are sectioned, exposing the erector spinae muscle and the central end of the ribs. A muscle-splitting exposure can be used if only one rib is to be resected but it may hamper good exposure (*Fig. 1265, B*). The erec-

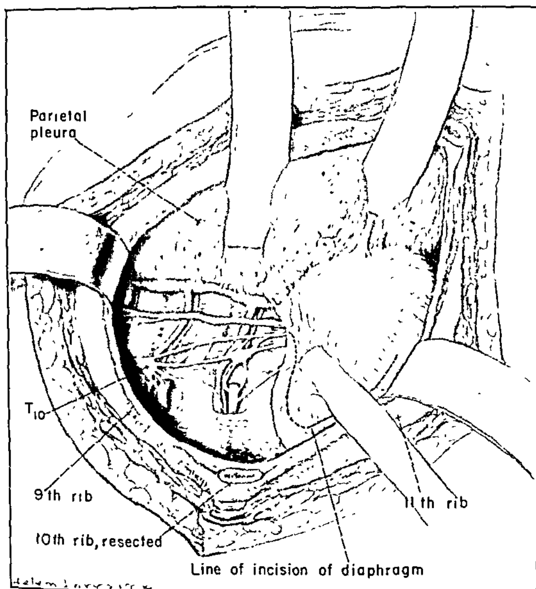



Fig 1268—Rib has been resected and pleura reflected from thoracic wall and diaphragm. Sympathetic chain and splanchnic nerves are well exposed.

by blocking sympathetic impulses and pain fibers traveling in the sympathetic system. The realm of pain-relieving procedures is expanding and sympathectomy for various abdominal discomforts is frequently carried out with excellent results.

## Operative Procedure

The operation is performed in two stages. The patient is placed directly on his side with the tenth rib over the kidney rest or point at which the operating table can be broken. The kidney rest is then raised or the feet and head lowered, producing a flaring open of the rib cage in the operative region. Proper positioning of the patient is an important point in securing adequate operative exposure. An incision is made over the entire course of the tenth rib, beginning about 5 cm. lateral to the vertebral column (Fig. 1267). The entire rib, or at least the major portion of

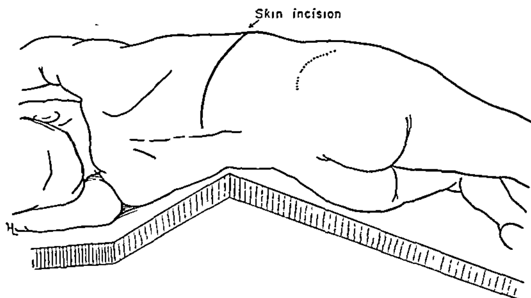



Fig. 1267.—Patient is directly on side with table break under tenth rib. Incision is made over extent of rib

it, is then removed after sectioning the overlying muscles. Only a small portion of the semispinalis muscle is sectioned as adequate exposure can be obtained without completely dividing this muscle. The underlying pleura is then dissected away from the chest wall. After dissection has been started in the proper plane of cleavage, gentle finger dissection will expedite rapid and safe exposure. An extremely important point in securing good exposure is adequate separation of the pleura from the diaphragm. The lung with the overlying pleura is then gently retracted with a Richardson retractor, exposing the entire splanchnic nerves and the major part of the thoracic sympathetic chain (Fig 1268). The splanchnic nerves are freed from their bed by blunt or sharp dissection and the celiac ganglion is pulled up into the thorax by traction on the greater splanchnic nerve. A portion of this ganglion is removed in the sectioning of the end of the greater splanchnic nerve. The sympathetic chain is then isolated and removed by dividing the rami entering the ganglia, the dissection extending above the uppermost ganglion sending fibers to form the greater splanchnic nerve. This usually entails removal of the ganglia up to the sixth or fifth thoracic ganglion.

Upon the conclusion of the thoracic portion of the operation, the diaphragm is sectioned from the sympathetic trunk outward. A sufficient extent of the dia-

phragm is sectioned to provide good visualization of the lumbar sympathetic trunk, which is isolated below the second lumbar ganglion and sectioned at that level (Fig. 1269). The renal and adrenal regions are easily explored by this approach. Large incisions in the diaphragm are sutured.

The muscles and skin are then closed in anatomic layers and the extrapleural space is aspirated by means of a catheter. If the pleura has been opened, as frequently occurs in this procedure, a second catheter is used to aspirate the pleural cavity. Opening the pleura has no deleterious effect, provided the lung is expanded thoroughly at the conclusion of the operation.

## LUMBAR SYMPATHECTOMY

### Indications

Lumbar sympathectomy is an extremely valuable operation in many cases of peripheral vascular disease. It is particularly beneficial in cases of vasospastic disease, such as Raynaud's disease, which usually occur in young individuals. In such instances early operation is indicated before pronounced anatomical changes occur in the vessels, but even in such cases the prognosis must be guarded.

In vascular cases exhibiting definite occlusive changes in the vessels, lumbar sympathectomy may still be of real benefit in properly chosen cases. Small irritative areas may cause spasm, which can be abolished by removal of vasoconstrictor impulses, and small arterioles may also have their caliber increased. Rarely there may be further diminution in circulation in the distal portions of extremities following sympathectomy, perhaps resulting from a shunting of blood around the terminal vessels, and therefore sympathetic block should always precede lumbar sympathectomy. Advanced age, however, is not in itself a contraindication to operation, as excellent results with regard to pain, intermittent claudication, and healing of ulcers can be obtained in elderly people.

Hyperhidrosis, while calling for surgical intervention more frequently in the upper extremities, may be sufficiently severe in the feet and legs to warrant operation In severe cases there may be actual maceration of tissue because of the profuse sweating which is readily relieved by lumbar sympathectomy.

Cases exhibiting evidence of acute loss of arterial flow to extremities, whether from blockage due to embolus or loss of continuity of vessel due to trauma, should have early interruption of sympathetic impulses in order to stimulate collateral circulation. Such interruption can be attained early by local anesthetic blocks, but sympathectomy is indicated as soon as the patient's condition will permit operation.

Causalgia and amputation stump pain will usually yield to sympathectomy if this procedure is performed early. If these conditions are chronic, however, ganglionectomy is of no avail

### Operative Procedure

The patient is placed supine on the table with the side of operation slightly elevated by means of a small pillow or sandbag under the hip. The incision is made in the direction of the fibers of the external oblique muscle and extends from the lower costal margin to a level just below the anterior superior iliac spine (Fig. 1270, *A*). It is placed about 4 cm. medial to the iliac spine and is usually about 15 cm.

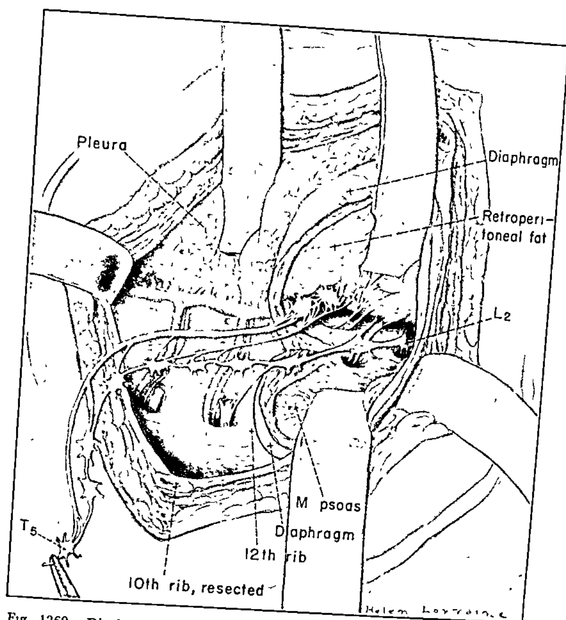



Fig 1269.—Diaphragm has been partially sectioned after dissection of upper thoracic chain and splanchnic nerves Lumbar chain is well exposed below the second lumbar ganglion and sectioned.

run cephalad whereas rami of other ganglia usually run caudad or transversely. The chain is isolated and removed from above the second to below the fourth lumbar ganglia. It must always be borne in mind that there are innumerable variations as regards the size and number of ganglia, and identification must rest primarily on the rami rather than the ganglia.

After removal of the appropriate ganglia the retractors are removed and the muscle layers will come into close approximation. A few sutures are placed in each layer. If it is desirable to perform bilateral lumbar sympathectomy it can easily be done by slipping the small pillow or sandbag under the other hip and repeating the procedure. The patient can be allowed out of bed on the day after operation, and total hospital stay is usually less than a week.

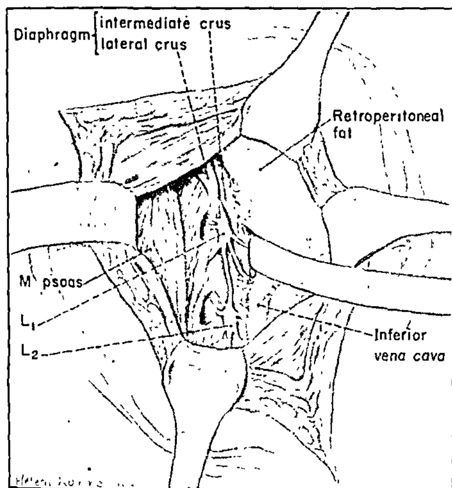



Fig. 1271.—Retroperitoneal structures have been retracted and the vena cava elevated to expose the lumbar ganglia

## SYMPATHETIC BLOCKS

### Stellate Block

Indications.—Stellate block with local anesthetic agents is indicated in a variety of conditions. Many reports indicate that it may be of value in cerebral thrombosis, but prognosis in such cases must be extremely guarded. In most instances where sympathectomy of the upper extremity seems indicated, it is advisable to perform a preliminary block to test the efficacy of sympathetic interruption. None of the available sympathicolytic drugs will adequately block impulses to a given extremity. It

in length. An alternate incision can be made transversely at the level of the umbilicus from the edge of the rectus muscle to the flank, but this incision requires some undercutting of the skin and subcutaneous tissue to expose the external oblique muscle. This muscle is split in the direction of its fibers and retractors are placed to expose the internal oblique muscle, which is then also split in the direction of its fibers at a level running just above the umbilicus. This exposes the transversalis muscle and fascia which is opened with due care to avoid injuring the peritoneum (*Fig. 1270*). Blunt dissection with the fingers is used to carry out extraperitoneal dissection of the retroperitoneal tissues. The dissection is begun well laterally and the abdominal contents are pushed medially to expose the psoas muscle. Excellent

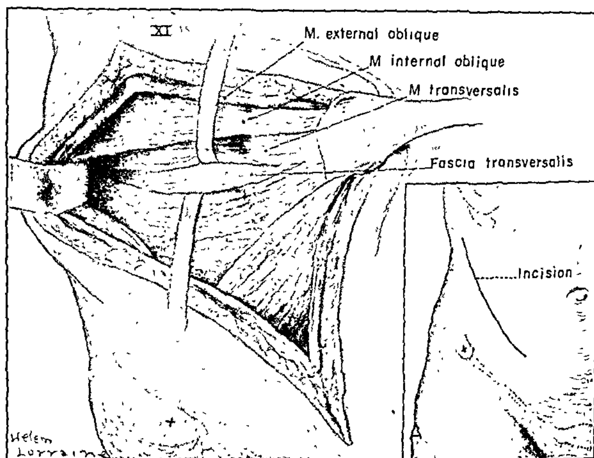



Fig 1270—*A*, Skin incision is in direction of external oblique fibers and is made 4 cm. medial to anterior spine of ilium *B*, Underlying muscles have been opened in direction of fibers

retraction is of extreme importance and can be obtained with a Richardson or similar retractor. The dissection is carried anterior to the fascia over the quadratus lumborum and psoas muscles. The thin fascia covering the psoas muscle, great vessels, and sympathetic chain is opened and dissected free. On the left side the sympathetic chain is located in the sulcus between the psoas muscle and the aorta, while on the right side the vena cava usually covers the chain (Fig 1271). The chain is tough and taut and is closely bound to the fascia covering the vertebrae. Many small vessels may cover the rami but usually do not need to be divided as the chain can be drawn under them.

Lymphatics may closely resemble the sympathetic chain but are usually looser and more friable. The second lumbar ganglion is identified by the fact that its rami

run cephalad whereas rami of other ganglia usually run caudad or transversely. The chain is isolated and removed from above the second to below the fourth lumbar ganglia. It must always be borne in mind that there are innumerable variations as regards the size and number of ganglia, and identification must rest primarily on the rami rather than the ganglia.

After removal of the appropriate ganglia the retractors are removed and the muscle layers will come into close approximation. A few sutures are placed in each layer. If it is desirable to perform bilateral lumbar sympathectomy it can easily be done by slipping the small pillow or sandbag under the other hip and repeating the procedure. The patient can be allowed out of bed on the day after operation, and total hospital stay is usually less than a week.

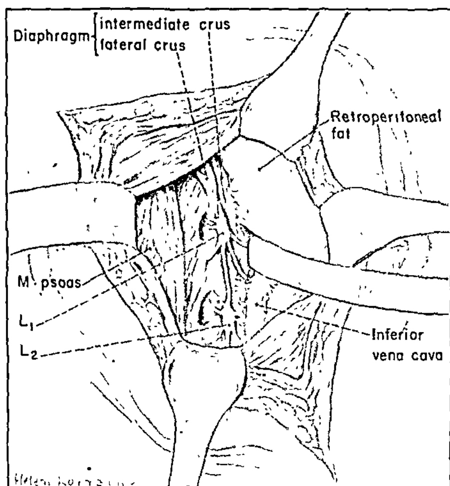



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must always be borne in mind that stellate block is not without danger, as deaths have been reported following this procedure.

**Method.**—Several methods of stellate block are available and good results can be obtained with any of them if sufficiently practiced One method is outlined here.

The patient lies down with the head and chest raised to about 45 degrees and the head rotated slightly away from the side of injection. After the skin is sterilized, the anterior surface of the transverse process of the sixth cervical vertebra is palpated behind the posterior border of the sternocleidomastoid muscle. The muscle, trachea, larynx, and neurovascular bundle are displaced toward the midline and the needle is inserted almost perpendicularly toward the transverse process of the sixth vertebra (Fig. 1272). Contact is made with the bone and the depressed skin is slid along

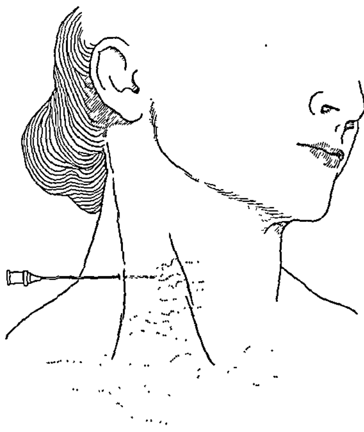


Fig. 1272.—The needle is inserted just behind the sternomastoid muscle directly toward the sixth cervical process. The neurovascular bundle is pulled forward when the needle is inserted

the needle Aspiration removes danger of being in a vessel or in the spinal canal, and approximately 5 c.c. of a dilute local anesthetic are then injected. The fluid diffuses along the prevertebral fascia and descends to reach the region of the vertebral artery The needle is withdrawn about 3 mm to a point where it feels free in the tissue and aspiration is again carried out. Then 15 c.c. of the local anesthetic are injected which diffuse in the tissue around the vertebral artery, the intermediate and the stellate ganglia.

If the injection is successful, there will soon appear ptosis of the lid, miosis of the pupil, and congestion of the conjunctiva. If such signs do not develop, a second injection is made with the needle inserted a little lower and directed slightly down-

ward. This method gives a block by descending diffusion and largely avoids danger of pleuropulmonary accidents which are common when attempts are made to inject the ganglion directly.

Paravertebral Block

**Indications.**—Paravertebral injections of local anesthetic to block sympathetic impulses to the extremities are most helpful diagnostic procedures. The value of operative intervention can frequently be foretold although failure of a block to produce marked benefit does not necessarily mean that operation will be of no benefit. In mild cases of causalgia or the shoulder-hand syndrome there may be lasting benefit from repeated blocks. With care the procedures carry only minimal danger and discomfort.

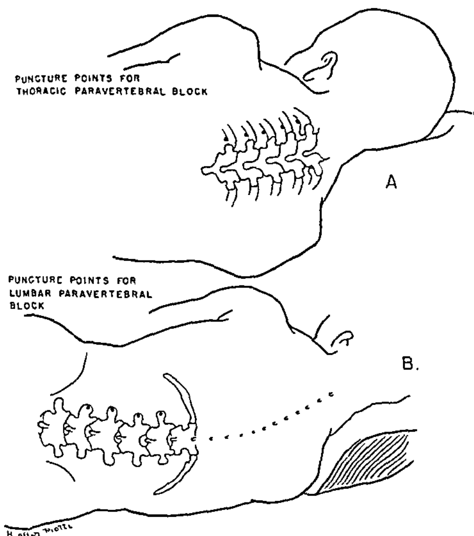



Fig. 1273.—*A*, Injection is made opposite the upper portion of the upper thoracic transverse processes *B*, Lumbar injection is made directly over the transverse processes

Alcohol injection of sympathetic ganglia is a more precise and dangerous procedure and should be performed only by those well versed in the method. The alcohol diffuses to only a slight extent, demanding accurate placement of the needle, and such precision can frequently be obtained only with x-ray study of the needles in place. In addition, there is severe pain if the alcohol enters the pleural cavity

and danger of serious complications if it enters the subarachnoid space These dangers can be avoided with exercise of utmost care, but a disturbing alcoholic neuritis of the nerves frequently cannot be avoided. Alcohol injection is, therefore, not indicated except in extremely poor surgical risks and here should be done by an experienced person.

Upper Thoracic Injection.—The patient is placed on his side with back and shoulders close to the edge of the bed, and legs and head flexed. The long axis of the vertebral column is kept straight by placing a pillow under the head. The principal landmarks are the spinous processes, and the injections are made 4 cm. lateral to these structures. The thoracic spines are imbricated, and therefore the tip of any spine lies over the body of the next lower vertebra. Usually the upper four ganglia are injected and the topmost injection is made lateral to the seventh cervical spine (Fig. 1273, *A*). *Skin wheals are raised and 10 cm. needles are introduced perpendicular* to the skin until the underlying rib or transverse process is reached. The tip of the needle is then manipulated caudally until it slips past the inferior edge of the bone. *It is then directed inward at an angle of about 25 degrees and inserted* 3 cm. further. Care must be taken to keep the point of the needle close to the vertebral body in order to avoid entering the pleura. The needle is aspirated to make certain that the subarachnoid space and vessels have not been entered and 10 c c of a dilute local anesthetic is injected. The same procedure is repeated opposite the three lower spinous processes.

Lumbar Sympathetic Injection.—The patient is placed on his side with the knees flexed. The spinous processes are again the principal landmarks and the injections *are made 3 cm. lateral to the upper edges of these structures* (*Fig. 1273, B*). The 10 cm. needles are inserted through skin wheals in a plane perpendicular to the back and will contact the transverse processes at depths of 3 to 6 cm. After reaching the transverse processes the needles are directed *slightly upward and medially and inserted an additional 4 cm Contact should be made with the body of the vertebra*, and, after aspiration, 10 c c of a dilute local anesthetic is injected. The injections should be made at the first, second, third, and fourth lumbar levels.

## Splanchnic Block

Indications.—Splanchnic block is indicated for the relief of pain in some abdominal conditions It is particularly valuable in controlling the pain of acute pan*creatitis which may be excruciating. In addition to controlling* pancreatic pain the block exerts a beneficial effect on the underlying pathology by abolishing spasm of the ductal system and increasing blood supply to aid in reducing the edema of the pancreas and surrounding tissues *Gall bladder pain may also be relieved by* this measure. In some hypertensive cases splanchnic block has been used to determine the possible benefits of sympathectomy, but in this regard it is not a very useful procedure

Method.—There are several methods for obtaining blocking of the splanchnic nerves. One plan utilizes repeated paravertebral blocks in the lower thoracic region where the anesthetic solution will block the ganglia and also diffuse around the splanchnic nerves. A skin wheal is raised 4 cm. lateral to the upper portion of the eighth spinous process (Fig. 1274). A 10 cm needle is then inserted perpendicular to the skin until the rib or transverse process is located. The needle is then partially

withdrawn and inserted in a more medial and caudal direction until the vertebral body is encountered. The needle must remain close to the vertebra to avoid entering the pleura. After aspiration to make sure that the needle has not entered a vessel or the subarachnoid space, 10 c.c. of a dilute local anesthetic is injected. If desired effects are not soon apparent, the procedure is repeated at the next lower vertebra and the other side is then injected. As the majority of the pancreatic and biliary pain fibers traverse the right splanchnic nerves, it often suffices to inject only that side.

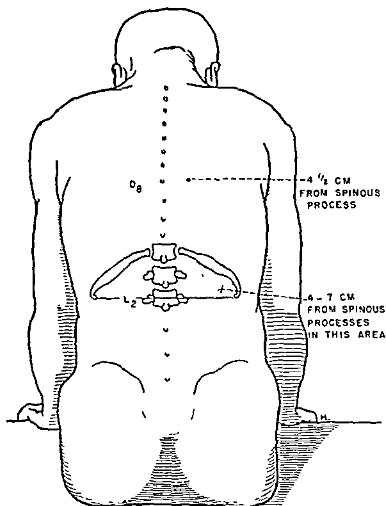



Fig. 1274—Paravertebral block can be made 4.5 cm. from middle and lower thoracic spines to block ganglia and splanchnic nerves. More direct splanchnic block is obtained by injection in the shaded triangle with optimum point being 7 cm from spine.

A more direct method of splanchnic block has become more popular in recent years and it avoids the possibility of puncturing the pleura. The patient can be lying on the abdomen with a pillow under the epigastrium or on either side. The injection can be made in any point of a triangle bounded by the lateral border of the upper lumbar vertebrae, the twelfth rib, and a line joining the spinous process of the second lumbar vertebra with the outer portion of the rib (Fig. 1274). The needle must be inserted at an increasingly acute angle as the site of injection moves laterally. One excellent point is 7 cm. from the spinous process of the first lumbar vertebra at the lower border of the twelfth rib A skin wheal is made and the needle is introduced at an angle to strike the vertebral body. It is then withdrawn

and inserted at a decreasing angle until it slips off the anterolateral border of the vertebra, and at this point is inserted 1 cm. farther. Aspirations determine that the needle is not in a vessel or the spinal canal, and 30 c.c. of dilute (1 per cent) local anesthetic are injected. Relief of pain can be expected in ten to twenty minutes.

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